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PREPARING HERBARIUM SPECIMENS OF VASCULAR PLANTS

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ACKNOWLEDGMENTS

Without the help and suggestions of my many colleagues in systematic botany, this paper could not have been produced. I particularly wish to thank Harold St. John and F. A. McClure for advise on the preparation of plant specimens in their specialties. The staffs of the U.S. National Arboretum and the U.S. National Herbarium have offered much kind advice for which I am grateful.

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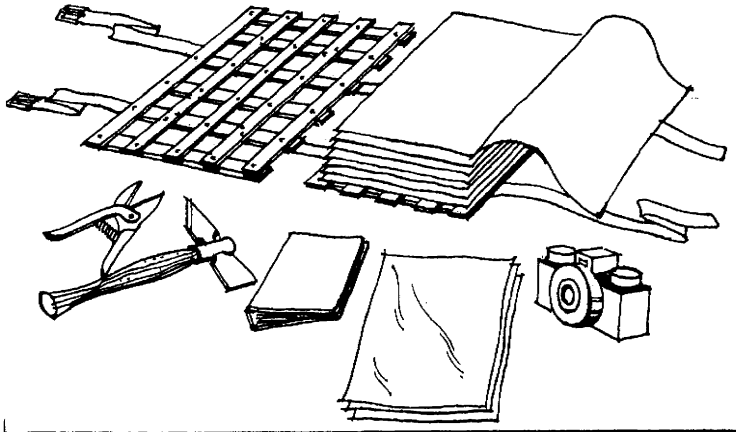
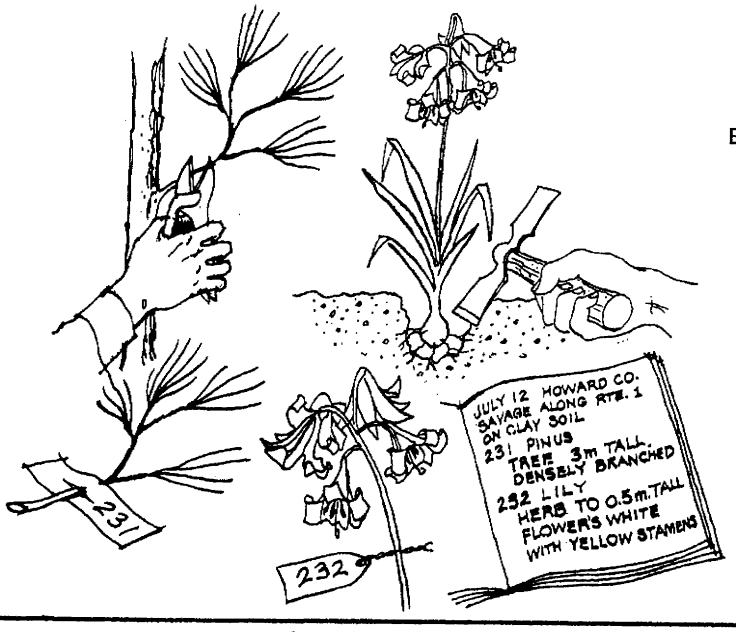
Short Guide to Preparing an Herbarium Specimen



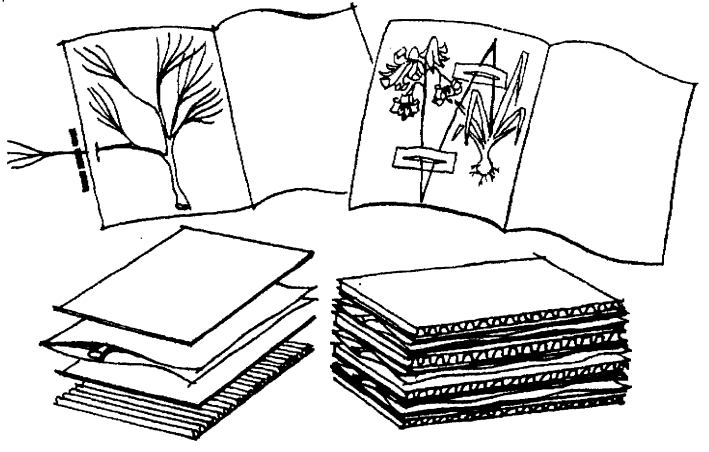
A. Assemble the equipment.

1. Prepare the press with folds of newspapers to receive the specimens.
2. Gather tools and supplies: cutting tools, digging tool, notebook, plastic bags to hold unpressed specimens, and a camera to record difficult-to-describe plant parts.



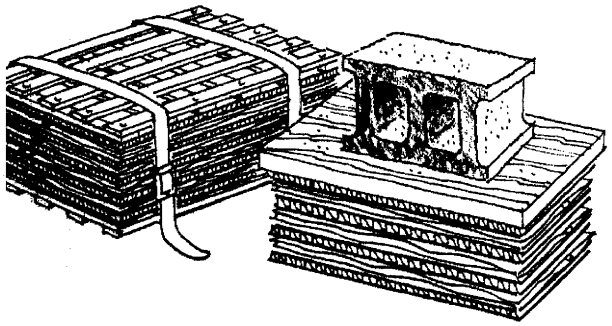
B. Collect the specimen and record the data.

1. Survey the plants to be collected to find the most representative specimens.
2. Cut or dig the selected plant parts.
3. Make detailed notes of observations that may be forgotten.
4. Place the specimens in a container for transport or in the press. If notes are made and separate parts collected, give the same identifying number to portions so they can be associated later.



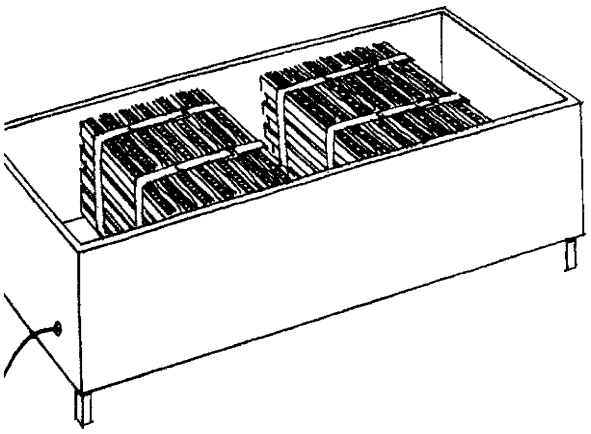
C. Prepare the specimen for pressing.

1. Place specimen in numbered newspaper fold.
2. Cut away excess parts, arrange leaves and flowers.
3. Write notes beside number in notebook; describe area, habit of plant, colors that may change, odors, and any special details.
4. Place fold between driers (adsorbent blotting paper) and corrugates (corrugated cardboard with channels running the width of the 12- by 17-inch piece) or heavy pads of newspaper.



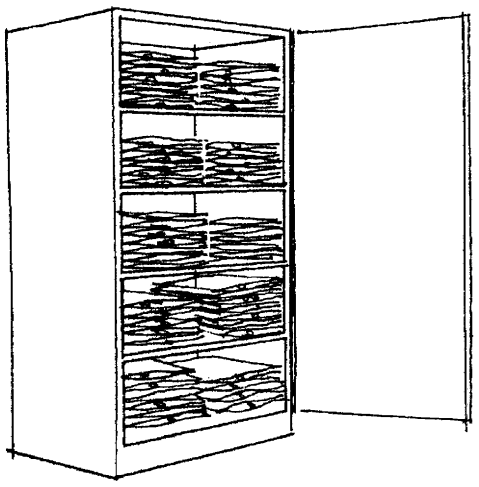
D. Press the specimen.

1. Press the specimen with its driers and corrugates tightly between press frames or weight heavily beneath board or books.



E. Dry the specimen.

1. Change driers or newspaper pads in 24 hours and thereafter as they become moist. Do not disturb the specimens in the newspaper folds.
2. When dry to the touch, test for incompletely dried specimens (incompletely dried specimens will feel cooler and ends will droop when lifted from the fold).



F. Store the specimen.

1. Store dried specimens in their folds tied between corrugates or mount on stiff 12- by 16-inch paper with bookbinder's Holland tape strips, casein, or plastic glue.
2. Label all specimens before storage or mounting.
3. Store only in insect-resistant furniture.

Additional, detailed information on preparing herbarium specimens can be found in the rest of this bulletin.

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PREPARING HERBARIUM SPECIMENS OF VASCULAR PLANTS

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THE HERBARIUM SPECIMEN AND ITS PREPARATION

The correct methods of preparing plant specimens for the herbarium are as many and varied as the correct methods of baking a cake. Every practicioner finds a convenient method that he will defend against all intruders. The truly correct method of preparing herbarium specimens is that which produces the most representative dried sample in the shortest possible time.

The Herbarium Specimen

The most important element in botanical collecting is the permanent record produced, which is a specimen or a suite of specimens representing a living plant (fig. 1). For most purposes, an identifiable specimen can be defined as one with either flowers or fruits, or both, because most botanical literature discusses the differences in kinds of plants in terms of reproductive structures. This is generally true for all groups of plants including the seaweeds, mushrooms, mosses, and ferns, as well as the seed-bearing plants. Speciments of ferns and seed-bearing plants tend to be more bulky and difficult to prepare so this bulletin will be concerned with these plants. These, in fact, are the "vascular plants" of the title, because they include in their structures a system of tubes for transport of liquid (the vascular system).

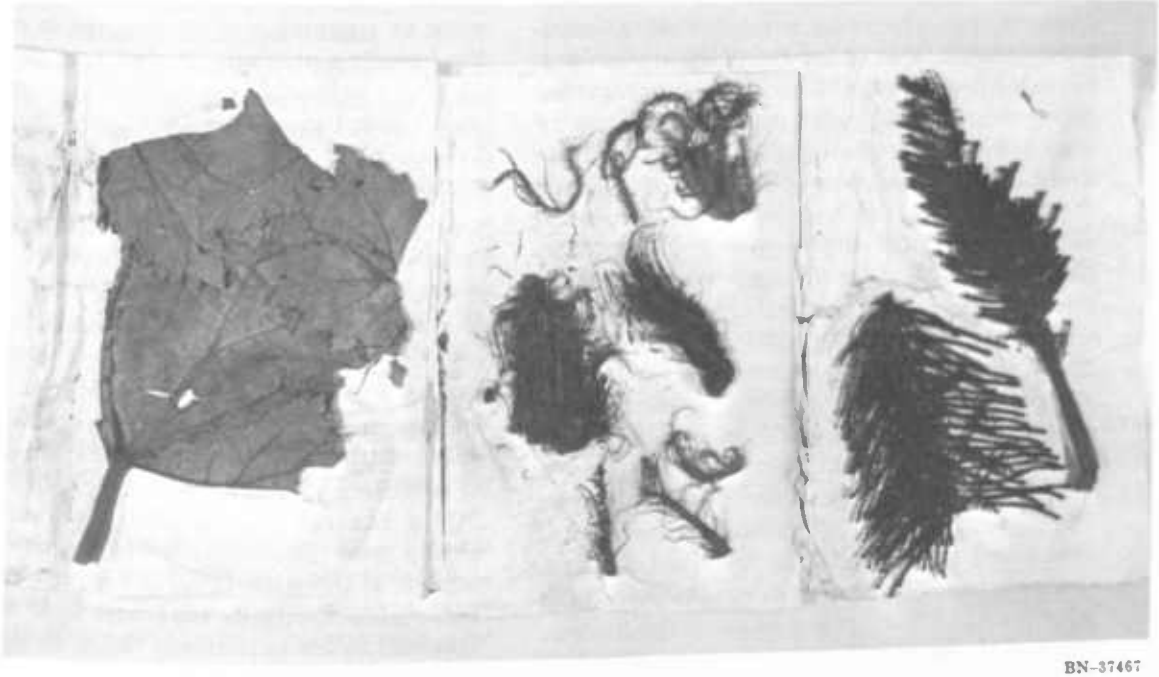

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FIGURE 1.—Suite of specimens representing *Gunnera peltata* Phil.

Plant specimens are kept in an herbarium (collection of herbs, literally, although the term is now used for any kind of dried plant collection). To facilitate the storage of specimens and to allow the greatest flexibility in exchanging or borrowing specimens, the herbaria of the United States mount dried, pressed plants on sheets of stiff paper measuring about 11½ by 16½ inches (28.7 by 41.7 cm.). Because there are a number of facts about a plant (height of tree, geographical place where the plant was growing, kind of area where the plant was found, colors, and odors) that do not show in the dried specimen, additional information is placed on a label that is fastened to the lower right corner of the sheet of mounting paper. Many plant specimens do not hold together well and some have only a few flowers, so the botanist dissecting the flowers wishes to preserve the dissected parts. He places all loose parts in folded packets glued to the mounting sheet. Sometimes the appearance of a plant defies description and the collector saves much time by photographing the plant before specimens are taken. Such photographs are usually fastened to the mounting sheet also.

Herbarium specimens are identified as accurately as possible and are then filed in standard-size manila folders with closely related species. These in turn are aggregated into groups of closely related genera and into families. Most frequently, several manila folders are stored in a pigeonhole in the herbarium case according to the Engler and Prantl scheme of classification (*16*) [1] so that an individual genus or species may be quickly recovered. (The Engler and Prantl classification attempts to group all plants in their natural relationship to one another. This is the most widespread of several systems of classification.) The earlier herbarium specimens become the standards against which later specimens are compared, and, thus, the accuracy of the identifications is critical. The more complete the specimen and the more detailed the notes on the label, the more accurate the identification can be.

Herbarium specimens are very important records. Perhaps the most important function of an herbarium specimen is to record the complexity that is a plant species. Botanists have long known that words or illustrations cannot replace an actual sample of a plant as a standard for comparison. This is recognized in the codification of rules for plant nomenclature where a type specimen is required as the base for a plant name. The first collection that is described as a new species becomes the type specimen against which all future identifications of this species must be measured. Any scientist doing research involving living plants should prepare an herbarium specimen for permanent record in case further work based on the same material is necessary or the original identification of the plant is questioned. Whenever samples of plants are submitted for any sort of analysis, a specimen of the plant from which the sample was prepared ought to be held as a record. Ever the amateur gardener may find that dried, pressed specimens of some of his plants may serve as valuable standards of size and identity for new cultivars tried in subsequent growing seasons. Anyone involved in the breeding of plants should preserve representative specimens as a check for the improvement or regression of characters in progeny in the breeding program. A few minutes spent in carefully preparing an herbarium specimen can save much time if the exact identity of a particular plant must eventually be known or recalled.

Preparing an Effective Herbarium Specimen

An effective herbarium specimen not only is identifiable and serves as a record of the species, but also shows the range of variation of the species in the place where the specimen originated. Although the standardization of the size of mounting paper in the herbaria of the United States has resulted in the universal exchageability and storability of specimens, it has tended, at the same time, to bias the collector in favor of a specimen that will look neat when fastened to the herbarium sheet. In spite of the fact that it must eventually fit a standard-size herbarium sheet, a sample should be selected first for its value as a representative of foliar size and variation, inflorescence size and varia-

[1] Italic numbers in parentheses refer to Selected References, page 26.

tion, and stem aspect of the population of the species. The specimen should be selected next for its complete normalcy unless that specimen is to show the damaging effects of fungal or insect attack. Finally, the specimen should be attractive once it is mounted if it is possible to prepare a pretty as well as a representative specimen. Many times it will be impossible to find representative specimens that are also attractive after they are pressed (fig. 2).

Collecting the Specimen

For most people, collecting the specimen is the most enjoyable part of preparing herbarium specimens. Because there is an element of fun and pleasure involved, there is sometimes a lack of understanding of importance of collecting representative and complete examples to go into the press. Often considerable search must be made before a suitable portion of a plant will be found.

TOOLS AND EQUIPMENT NEEDED.—Tools frequently are a matter of personal preference. A New Englander finds an ax easy to use, but a Mexican generally prefers a machete. A few tools are useful enough to be recommended for everyone who wishes to collect plants.

Field pressing equipment is needed to prepare adequate botanical specimens. A field press may be made of any type of material that can be used as end boards to exert uniform pressure over a 12- by 16-inch area. Many botanists carry a press with fiber or plywood ends, but the standard lattice press frame made of crossed strips of a tough wood like ash, hickory, or oak is very satisfactory (fig. 3). As a collecting press, the frames may be held together with sash cord or web straps, or a special system may be installed in which the fastening on one side of the frame acts as a set of hinges so the press will open from one side only.

In the past, botanists often carried a tin box known as a vasculum into which plant materials were placed pending an opportunity to press them. With the multiplicity of plastic bags now available, most botanists use these for field carrying because they take up little space before they are filled and are easily disposed of after use. When using a general repository for a number of specimens before pressing them, it is well to remember that they must be bundled and labeled to prevent mixing if there are several collections of the same species. Also, flowers and other structures tend to become dislodged, so extra material should be gathered to ensure enough to make up the required duplicates when the plants are pressed.

A short-handle field pick is one of the most useful tools that can be found for collecting herbaceous material. Often, the soil is so compact or full of rock that garden trowels and similar implements are ineffective. Unfortunately, the demand for special botanical field picks with a narrow, hatchetlike blade on one side and a small mattocklike blade on the other side is so small that they are very difficult to locate. Army entrenching tools and similar make-do aids can serve a very useful purpose in collecting. If collecting is to be done over any distance, though, the lighter the digging tool, the better, because the load of plant specimens will grow heavy and can become rather bulky.

Cutting tools are indispensable for efficient collection and preparation of specimens. A pocketknife will serve for many uses but it will not work effectively on twigs greater than about three-eighths inch in diameter if the wood of the plant is very dense. A garden pruning tool of the knife-on-anvil type of heavy forged construction will cut through most wood up to about 1 inch in diameter. For heavy cutting jobs such as tree felling, an ax is the tool usually employed although a sharp machete is nearly as effective if the user is skilled. A machete is not recommended for amateurs because on a downstroke the heavy blade can cut nearly through a leg.

Unless a collector is skilled at sketching, a camera is a necessary part of the collecting apparatus. Many details about the appearance of plants in the field are both difficult to express and require more extensive field notes than most people wish to write. The camera will capture the shape and manner of branching of a tree much more surely than a note. If a plant is bulky and must be divided into portions before pressing, a photograph of the intact part taken with a scale will provide a descrip-

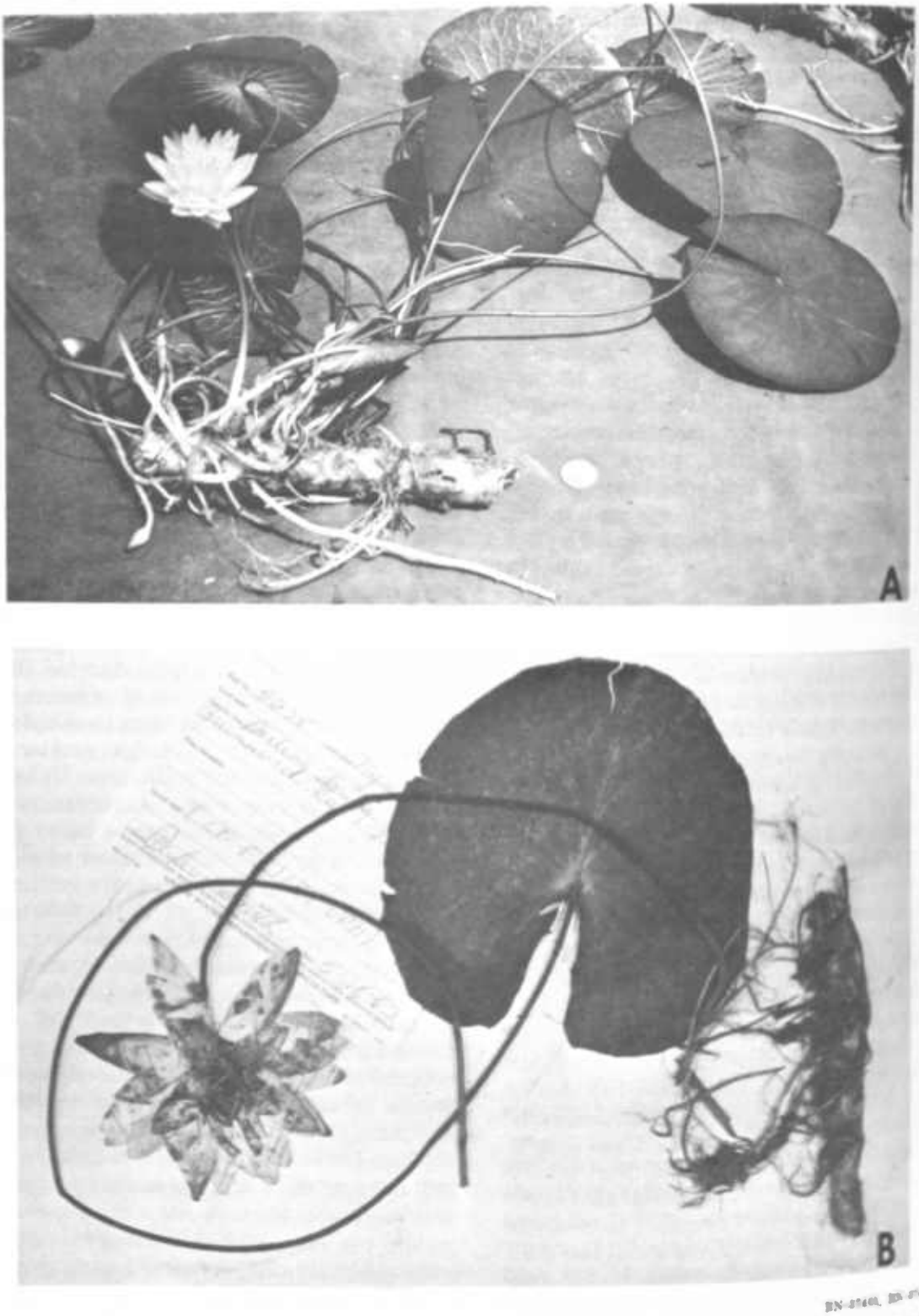

FIGURE 2.—*A*, Plant of *Nymphaea odorata* Ait. as it was collected; *B*, dried, pressed specimen of the same plant
newsprint fold with a field label.

tion of shape and size with no further effort on the part of the collector. Unfortunately, color films are not yet permanent enough to be relied on for color recording, so it is still advisable to note the colors of plant parts before placing the specimen in the press.

PROCEDURES AND SUGGESTIONS.—When collecting specimens in a new area, make a short survey of the amount of material that may be available, the kinds of terrain that will have to be crossed, the condition of the available plants, and an evaluation of the amount of time the job is likely to consume. In this way, the more important specimens can be collected first, and the less important plants can be left for another time if the collector must allow sufficient time for preparing difficult-to-press specimens and recording additional notes for special material.

After making the initial survey, collect the more delicate specimens first so that they may be packed away safely and will not be destroyed by tougher plants laid on top. If time runs out and light fades, the more harsh plant materials can be packed away in a bundle and will still be in good condition the next morning.

Directions for collecting an individual specimen are difficult to give. Perhaps the best advice is to know something about the taxonomy of the group to which the plant belongs and then use your imagination in selecting material for representative and complete specimens. Hard-and-fast rules for making a perfect specimen can lead to somewhat less than representative specimens. Although it is admirable if the specimen is beautiful as well as representative, it is much more important that it is representative. The specimen should show the range of variation of the parts of the individual plant. It should also show the range of variation of the population of the species. Thus, more than one herbarium sheet may be required.

Ordinarily, small herbaceous plants must be

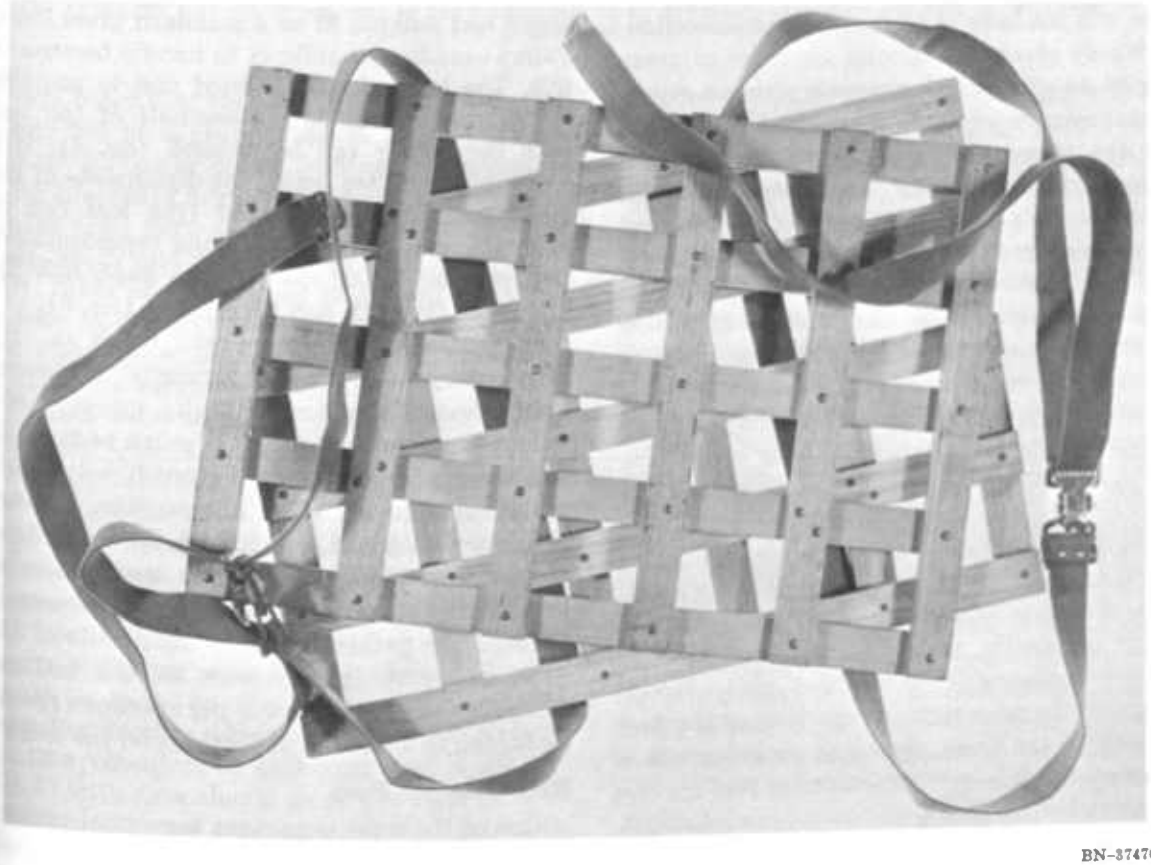

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FIGURE 3.—Lattice-type press frames and web trunk straps with quick-release buckles.

collected in quantity so that each herbarium sheet will consist of several plants. Some small plants fit neatly one to a sheet with one or two bends in the stem. All small plants should have the root system included with the specimen, and a note should be made as to whether the plant is an annual, biennial, or perennial.

Some herbaceous plants are much larger than the press sheet will accommodate, and an appropriate portion of the plant must be chosen to place in the press. Select a plant with intermediate-size foliage and inflorescence; include on the sheet a separate leaf of the largest size found on the plant. If the leaves along the stem are crowded and overlapping will obscure details of size, shape, and other features, remove a number of the leaves, but do not remove petioles or bases that indicate points of attachment. A large, complex inflorescence must be similarly thinned. Many of these thinnings can be pressed separately and packed as extra flowers and fruit so that parts of the whole specimen will not have to be removed for dissection.

Woody plants are usually too large to press whole. As with large herbaceous plants, a representative portion of the plant must be selected for the press. Always look over the shrub or tree carefully if it is large or in dense growth. Many plants produce radically different foliage on the outside of the plant where light is plentiful and inside or underneath where the leaves are constantly shaded. Also, foliage on shoots produced after a tree or shrub has been severely damaged or on shoots arising from the trunk is often much different from the foliage usually found on the same plant. In some plants, the foliage on flowering branches is different from that on sterile branches. Specimens should also show the older branchlets with the manner of branching typical of the species. When a specimen of a deciduous woody plant is to be as complete as possible, it is obviously impossible to collect flowering, fruiting, and winter specimens at the same time. At the time of the first collection, the plant should be marked with a permanent tag securely fastened so that curious birds and children will not be able to remove it. Subsequent collections can be made from the same plant. Often it is helpful to remove a small piece of bark to be included with tree specimens.

A few special problems are sure to come up sooner or later. One of these is pressing large underground parts of herbaceous plants. These can be treated in the manner described for fleshy stems and inflorescences. (See p. 19.) Sections are cut to show the length and the thickness of the part. Whenever possible, include material to show the outside surface, particularly of bulbs, because this surface is often important in determining the identity of the plant. Some plants will have a heavily tufted fibrous root system. Because this root system will be too bulky in the press, trim it to thin it down. If at all possible, always include enough rhizome to show the sequence of growth and branching. Grasses and sedges that grow as clumps must be divided before pressing. When this is necessary, the label should indicate that only a part of clump was pressed.

A few plants will have leaves so large that a single leaf will not fit on a standard press sheet. Palms usually are difficult to handle because of this. The leaf may be divided just to one side of the midrib and about one-half of the leaf with the petiole can be pressed (fig. 4). If a half leaf is still too large, the dimensions of the whole leaf should be noted (the leaf can be photographed with a scale) and representative portions, including the tip, the base, and the middle of the leaf, can be pressed (fig. 5).

In general, a little care will result in very satisfactory herbarium specimens. Whenever bulky stems interfere with the pressure distribution in the press, a few extra pads to fill out the space will result in much better and smoother samples. If at all possible, arrange leaves or fold a leaf so that both the top and the underside of the leaves may be seen. A similar arrangement for large flowers is necessary. Because the petals will hide the details of the calyx in some species such as the mallows (*Hibiscus* spp.), one flower per specimen should be turned to show the underside and the calyx.

Recording the Data

One of the most important aspects of preparing an effective herbarium specimen is recording accompanying data. Although the collector

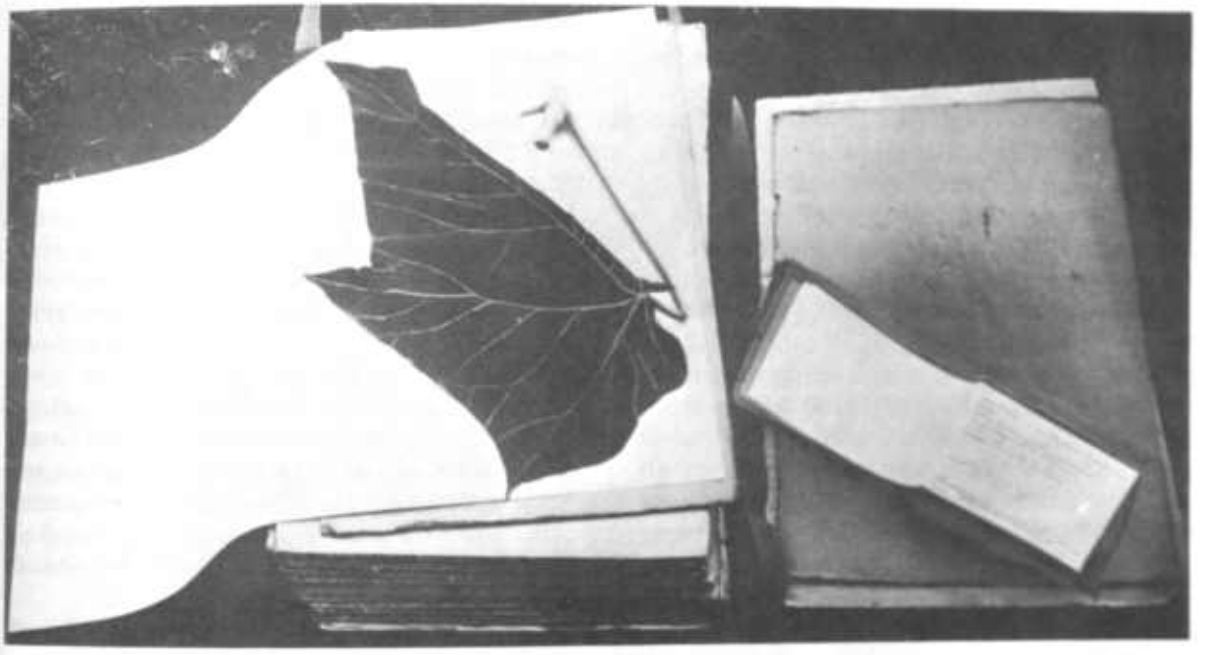

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FIGURE 4.—Large leaf cut to one side of the median line to fit newsprint fold. Note the stub of the petiole of an opposing leaf to show leaf position on the stem.

always hopes that the vivid colors of a beautiful flower will be captured, this is rarely the case. Almost all flower colors undergo some change in the process of drying. Similarly, odors vanish for the most part, although the members of the mint family and a few others may retain some odor. Sizes and shapes of plants often cannot be seen in the prepared specimen. These facts and many other details are needed or helpful in making a correct identification.

Correct ways of recording data about plants are many. One of the most important facets of the data-recording process, though, is to record the data on the spot, or as soon afterward as possible. Although a few hours do not seem to be much time, the kaleidoscopic impressions from a full day's field work are very difficult to sort late in the evening. Each time it is necessary to place specimens in a field press, all notes should be made on the plants going into the press. If collecting is being done by placing material in a vasculum or collecting bag, a slit tag (fig. 6) with data should go on the stem of each collection because this material will probably not be placed in the press until the end of the day.

After the plant specimens are prepared for drying, the permanent recording of field data can begin. All the temporary notes made during the collecting are now transferred to a record book or card, preferably of good-quality paper. The inscription is made with a smear-free, waterproof ink or pencil. For ease in relating data in the record book to the dried specimens, a serial number system is used and the same number is placed on both the covering press sheet and the margin of the book. A number of collectors have elaborate schemes whereby the number indicates the collection date, locality, or other information, but this serves little purpose unless the numbers are to be used in a special statistical study. A few collectors have initiated a new number series for each collecting trip or for each year. This is not a good practice because the repeating numbers may be easily confused if the specimens are permanently deposited in a working collection and monographers cite the label data. More complex number systems are more frequently misquoted.

What should the record include? One of the most satisfactory answers to this is received from an herbarium label (fig. 7). At the top

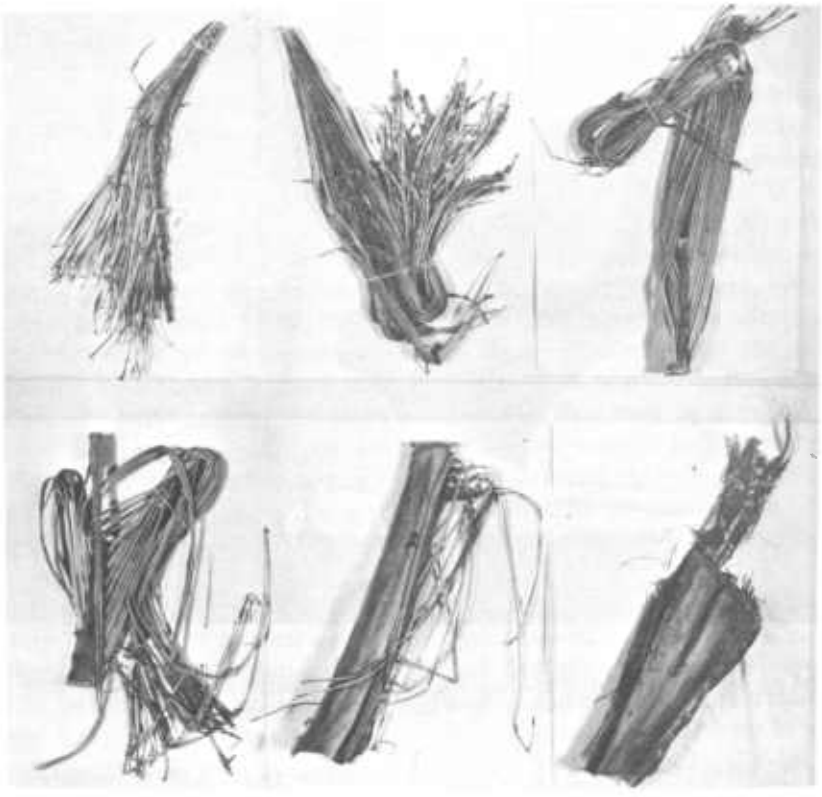

FIGURE 5.—Specimen leaf of *Juanea australis* Drude prepared in sections.

of the label the country or other major political area is noted most often; for example, "Plants of Zambia." Although the name of the institution sponsoring the collection may appear at the top, this is generally better recorded at the bottom of the label since that name is not essential to an understanding of the biology of the plant. Beneath the top line at the upper left, the collector's number is sometimes inserted or it may be inserted immediately after the collector's name near the bottom of the label. The scientific name of the plant appears at the top of the label, after the country or area is noted. At this point on the label, it is convenient to leave sufficient room to include notes about plant size, flower color, fruit shape and size, and any other information about the individual specimen. These notes must be placed on the label by hand or typewriter. Below this the geographical information in gradually decreasing magnitude of area is detailed; for example "Maryland, Howard County, south of Baltimore, along U.S. Route 1, near Savage." Any information concerning the habitat, soil, and moisture conditions can be noted next. The bottom line on the label is usually the name of the collector and the date on which the collection was made.

Obviously, considerable amounts of information can be accumulated about an individual specimen. The problem of recording all of this in the field book is simplified by using the geographical information and the date as the heading for a block of numbers representing specimens collected in the area. Under each number, only information about the individual plant is recorded. With this system, it is possible to accommodate all the information to be recorded into a standardized spacing so that the collector's numbers at left-hand margin of the page can be stamped with a consecutive numbering machine before going into the field. An asterisk beside the first number at a new locality indicates that the geographical information and data will be found at the top of the page.

The order of information on the label has become fairly standardized because professional botanists usually collect 5 to 10 duplicate specimens of interesting plants for distribution to a number of herbaria. The problem of placing all the information on the label is then simplified by having printed labels made for blocks of numbers and the typist has only to fill in the collector's number and the notes about the individual plant. If the number is placed at the upper left just over the space for the scientific name, all the typing can be done with one positioning of the label; if the number must be placed after the collector's name, the label must frequently be repositioned in the machine. All permanent labels for plant specimens should be typed or clearly printed so that there is no chance for error or confusion later.

Pressing the Specimen

Actual pressing of the herbarium specimen involves two problems: (1) Pressure sufficient to prevent curling of leaves and other plant parts during drying; and (2) removal of the moisture in the plant tissue as rapidly as possible without changing the appearance of the specimen. The first problem is solved easily by providing surfaces on either side of the plant specimen to hold all the organs in place. Almost all professionally prepared specimens are pressed in a sandwich involving a folded newspaper page to hold the specimens between two sheets of adsorbent (blotting) paper that are in turn flanked by two pieces of corrugated cardboard (corrugates) in which the channels run the width of the board. If all the elements of the sandwich are cut to a standard size of about 12 by 16 inches, there will be no difficult fitting specimens to the size dictated by the mounting paper. In an emergency or for only a few specimens, thick pads of newsprint can be substituted for blotting paper and corrugates.

Because corrugated cardboard eventually collapses, some collectors prefer to use sheets of corrugated aluminum. These are commercially available through biological supply houses.

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FIGURE 6.—Slit tag on stem of collected plant, containing data to distinguish plant from other collections of the same or similar plants.

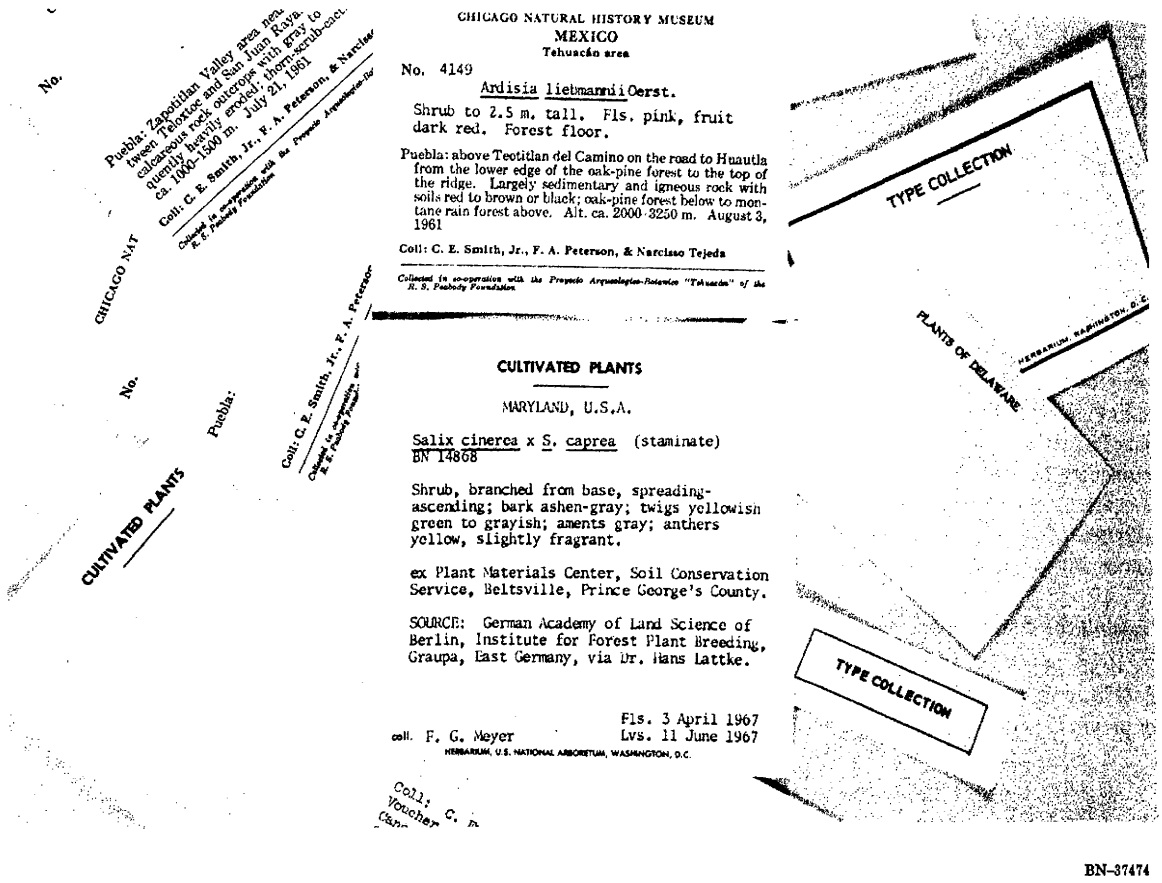

FIGURE 7.—Examples of labels, with basic information printed and notes about the individual collection typed.

Even though these aluminum corrugates stand up well under hard usage, it should be borne in mind that they weigh more than cardboard corrugates, the edges can inflict annoying cuts until they have been used long enough to become rounded, and they are too expensive to be abandoned after use in the field. Furthermore, they cannot be used to reinforce bundles of dried specimens as can cardboard corrugates.

Pressure is applied to the specimens to be pressed by any available and practical means. Large screw-type book presses and pieces of wide lumber weighted down with stones or bricks have both been used. For repeated use, the more easily handled press frames made of crossed ash or oak strips riveted at the crossings with large copper rivets provide uniform pressure when held by two web trunk straps or ropes tied with slip knots (fig. 3, p. 5). Usually straps with quick-release buckles are cut to the length needed to encompass the largest stack of specimens that might be placed in the press. Placing more than 60 to 90 specimens in a press, depending upon the bulk and shape of the plant material, often results in poor-quality specimens unless extra care is taken to distribute pressure evenly.

Plant press frames are readily available from biological supply houses or they can be easily made of slats of well-seasoned ash, hickory, oak, or other tough, flexible wood. Strips ¼ inch (6 mm.) thick ripped from the edge of a dressed board 1 inch (2.2 cm.) thick with a straight grain are ideal. Use five pieces 16 inches (40.5 cm.) long and six pieces 12 inches (30 cm.) long to form a lattice. All the longer pieces should be placed on the same side of the lattice. The ends of each piece are drilled and fastened into place with a copper rivet. Within the lattice, the crossings of the slats may be

nailed with brads. The accompanying plan illustrates the construction of a usable press frame (fig. 8, *B*). (See also fig. 3, p. 5.)

Drying the Specimen

Ordinarily, each specimen is laid into a fold of newsprint in the field press or at intervals as the collecting bag or vasculum is emptied. After they have been collected, specimens should not be left unpressed any longer than necessary. Although enough material for 2 or even 3 specimens may be crammed into a single fold under emergency conditions, this is not recommended as a general practice. Leaves and inflorescences tend to become entangled and stems make pressure marks on leaves and petals.

To set up a drying press, each specimen-bearing fold is enclosed between two driers (adsorbent paper) and adjacent driers are separated by corrugates. The press sequence, starting from one end, is as follows: corrugate, drier, fold with specimen, drier, corrugate, drier, fold with specimen, and so forth. Some botanists use only one drier per fold, but two driers per fold tend to mold better around stems of woody specimens and produce smoother leaves and flowers. Whenever specimens with particularly bulky stems, fruits, or flowers are put in the drying press, additional packing of folded driers, newsprint, or specially cut corrugates must be inserted both to apply proper pressure on thinner plant parts and to allow the press to stack evenly. Uneven stacks always tend to squirt out on the bulky side when pressure is applied and few things are more conducive to frayed nerves than an unruly press after a hard field day.

If this problem is frequently encountered, it

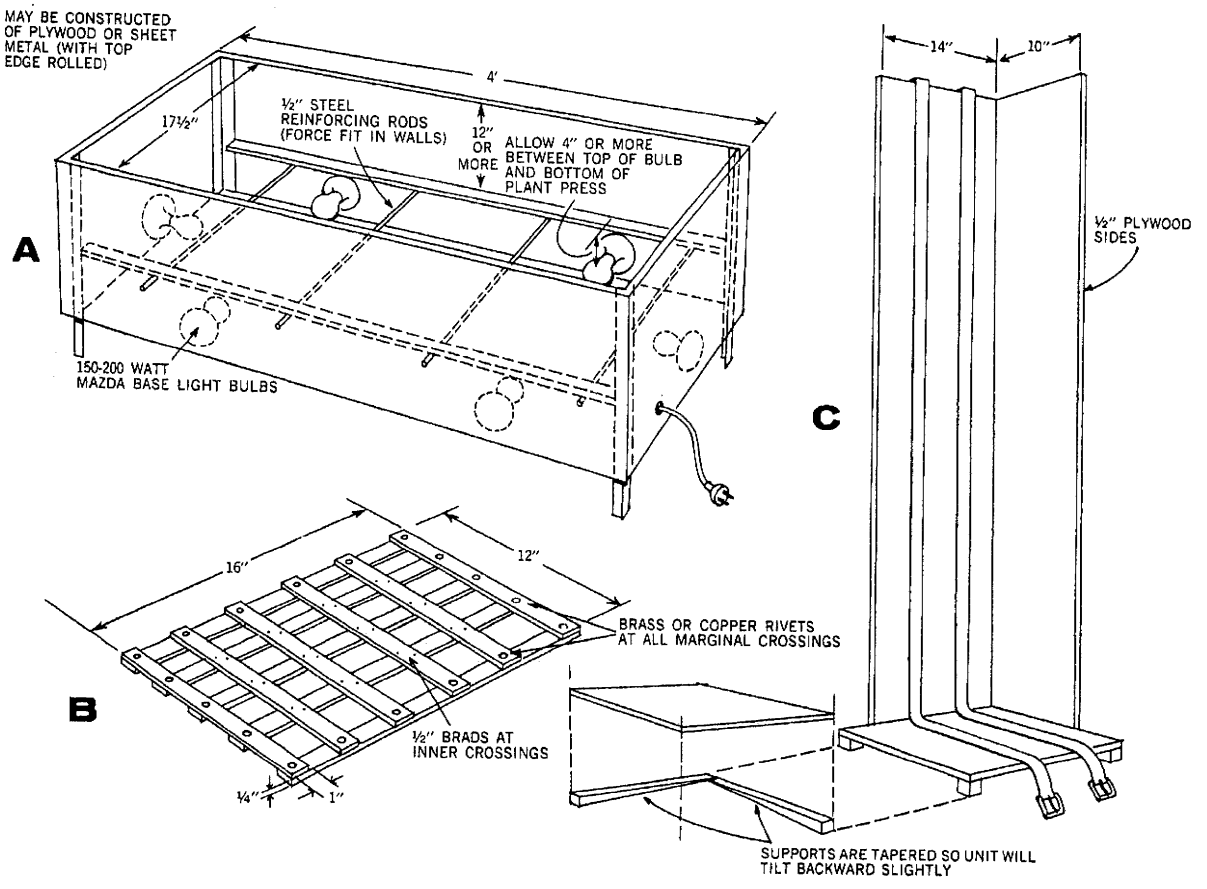

FIGURE 8.—Designs for: *A*, Heated drying rack; *B*, lattice-type plant press frame; *C*, stacking corner.

will be well to use specially cut blocks of urethane foam to fill out the press. This material is now frequently used for upholstering and is available in furniture repair shops. With a razor blade or other very sharp instrument, blocks and strips of an appropriate size and shape can be cut to fill in around a bulky plant part. If the foam fill block is cut two or three times as thick as the bulky plant part, pressure in the press will mold it into place so that thin leaves and flowers will be flat. The foam fill block is apparently sufficiently porous to allow moisture to escape. However, be cautious in the use of any padding material. Too much padding will result in the accumulation of moisture in the padding with a resultant delay in drying of the specimens, which may lead to mold formation or other undesirable results.

After the stack for the press has been assembled (i.e., corrugate, drier, specimen, drier, corrugate, etc., which are assembled horizontally), the press frames are put on the ends. The stack is held together and pressure is applied by two straps or ropes. It is usually most practical to have the buckles or knots along the axis of the press. If these are placed strategically near the far end of a large press stack, then the proper pressure can be achieved by laying the press on the floor, placing the feet on the press frame most distant from the buckles and pulling both straps evenly toward the feet. The side on which the buckles or knots are located will pull up faster than the other side. The press will have to be stood on one end and the press frame on top pressed down on the high side so the strap or rope slips around and the press frames are parallel. This may have to be repeated as pressure is applied.

Theories concerning the amount of pressure to be applied to drying specimens are many. Some botanists apply only light pressure immediately and tighten the press gradually as the specimens dry. However, pressure becomes less as the specimens lose water and the tissue becomes thinner. With woody plant material particularly, I find that the more pressure applied initially, the better, because the driers and corrugates then mold around the thicker parts and leaves are more wrinkle free. Two bad effects from too much pressure are: (1) The corrugates may be so completely collapsed that the air passages are blocked (their job being primarily to carry moisture out of the press); and (2) fleshy plant parts may be crushed and smeared into an unrecognizable mass. I have never been strong enough to achieve the former with fresh strong corrugates although reused corrugates collapse eventually. On one or two occasions, I have mashed a portion of a specimen. This clearly proves that the specimen should have been sketched or photographed and sectioned in the first place.

The straps or ropes will usually have to be tightened once or twice during the initial stages of drying. As plant material loses moisture, it shrinks. If the pressure on the press is not adjusted about every 8 hours, the leaves and flowers may wrinkle.

When aluminum corrugates are used, too much pressure can result in parallel pressure marks across the specimens. The more coarse the corrugation in the aluminum, the more likely this is to happen. Although this problem may be solved readily by less pressure, it frequently can also be solved by adding an additional drier on each side of the specimen fold.

If no source of artificial heat is available, the completed press should be placed in the sun during the day and under cover at night. If the press is so oriented that the prevailing breeze blows through the channels of the corrugates, drying will be more rapid. If the collector is operating a field vehicle, the press may be tied on top so that the air movement caused by the movement of the vehicle will flow through the corrugates. In open country with low humidity, specimens will dry very rapidly on a moving vehicle.

At the end of 24 hours, the press should be opened and the driers and corrugates completely changed so that each newsprint fold is surrounded by dry material. Although it is possible to open folds with specimens with harsh foliage at this point, do not attempt to look at delicate specimens. In their semidry condition, they will partly stick to the newsprint and collapse into a mass as they pull free. The material should have been arranged when the specimens were originally placed in the drying press. All of the moist driers and corrugates

must be thoroughly dried before reuse. These are generally spread in the sun. If the schedule for changing the press can be so arranged that driers and corrugates hot from the sun can be used, then drying of the specimens will be hastened.

Whenever possible, use artificial heat to dry specimens. In some areas of high atmospheric humidity, it is impossible to dry specimens without artificial heat. In other areas, artificial heat may not be mandatory, but it will be a definite help in drying specimens of fleshy plants.

Any source of heat is usable, as long as it can be channeled through the corrugates of the press. However, open campfires are far from desirable because a whole press full of specimens may be lost through fire in the later stage of drying. There is, of course, the added disadvantage of soot from an open flame.

In remote areas, kerosene and gasoline stoves and lanterns have been effectively used to dry specimens. Generally, the press is suspended above the heat source, high enough to prevent its catching fire. A metal baffle between the flame and the press will guard against a hot spot and distribute the heat more effectively. A cloth skirt tied around the press and nearly touching the ground improves the efficiency of the drying.

Wherever electricity is available, an efficient drier can be assembled by using light bulbs as a heat source. 100-watt or larger bulbs are best, and there is usually little danger of getting too large a bulb because very large wattage bulbs rarely fit into a Mazda socket. The press is suspended about 6 inches above the light bulbs. Again, a cloth skirt tied around the press and nearly touching the floor improves the efficiency of the drying. The light bulbs must not be allowed to touch any combustible material.

If the volume of plant material to be pressed is very large at any one time, it is convenient to have a heated drying rack to remove moisture from the press. The most simple form of drying rack consists of a frame to support the press with a skirt and a source of heat underneath such as a number of 100-watt light bulbs or serveral kerosene lanterns. A modified version of a large laboratory oven can be used if there are provisions for venting away the moisture coming from the press.

The drying rack shown in figure 8, *A* (see p. 11) can be constructed of sheet metal or plywood. The only critical dimension is the inside width (17½ inches) to accomodate the length of the press frames, newsprint folds, and other components of the press. If the inside width is too great, most of the heated air will pass around the press instead of through it: if the width is less, it will be difficult to get the plant press in and out of the drier. Be sure to allow air space at the bottom for good circulation. It is most important to keep the press far enough above the light bulbs to avoid a fire. The amount of heat can be regulated easily by unscrewing one or more of the light bulbs.

A final device to use when a large number of specimens must be processed is not necessary but is very convenient. The drawing in figure 8, *C* (see p. 11) illustrates a stacking aid so that materials being loaded in a press are neatly positioned and tilted into a corner, lessening the danger of the pile's collapsing just as the last specimen is placed on the stack. The dimensions of the stacking corner may be varied to suit personal preference, but it must be remembered that both wedges must be cut at the same angle so that the base will set squarely on the floor or table. If press straps are laid in place with the bottom press frame before starting to stack specimens, the completed press can be closed for easy removal from the corner.

Pressing Problem Plants

Because there are many problems that will be encountered when preparing a wide range of botanical specimens, detailed solutions for specific problems will be discussed in this bulletin, beginning on page 15. However, a few problems will be encountered when preparing specimens in the Temperate Zone and solutions to these problems will be suggested here.

One of the largest groups of plants, percentagewise, in the Temperate Zone flora is the gress-sedge complex that covers vast areas of meadow, roadside, and marsh. Although it is unlikely that the beginner will attempt to press these kinds of plants initially, he will soon become aware of their prominence. All collec-

tions of grass and sedge plants should include the underground parts so that stolons, rhizomes, and roots may be seen. Since a large part of the taxonomy of these plants is based on the fruiting inflorescence, it is very important to choose specimens that have at least a few nearly mature fruit. The stems of grasses and sedges are often slender and wiry. Leaves are generally numerous and often they are long and flexible. This combination of characteristics leads to untidy specimens with stems and leaves protruding from the press in all directions.

To corner the errant ends on such material, lay the base of the plant at the bottom of the double fold of newsprint and straighten out the leaves and stems beyond the top edge of the sheet. Lay a stiff object (stick, machete edge, cardboard) across the leaves and stems within the area of the press sheet, and fold the top of the plant across this to the bottom. While still holding this fold in place with one hand, slip a previously slit paper strap over the fold (fig. 9). Some collectors make a slit in the press sheet into which the folded stem and leaves are inserted. The folding process can be repeated until the whole plant is on the press sheet. It is unwise, though, to use more than three folds on a specimen. If a plant is so tall that it requires more folding, it should be cut into two or more portions. The first herbarium sheet of the series will then display the basal portion of the plant and the second sheet will display the top and inflorescence of the plant.

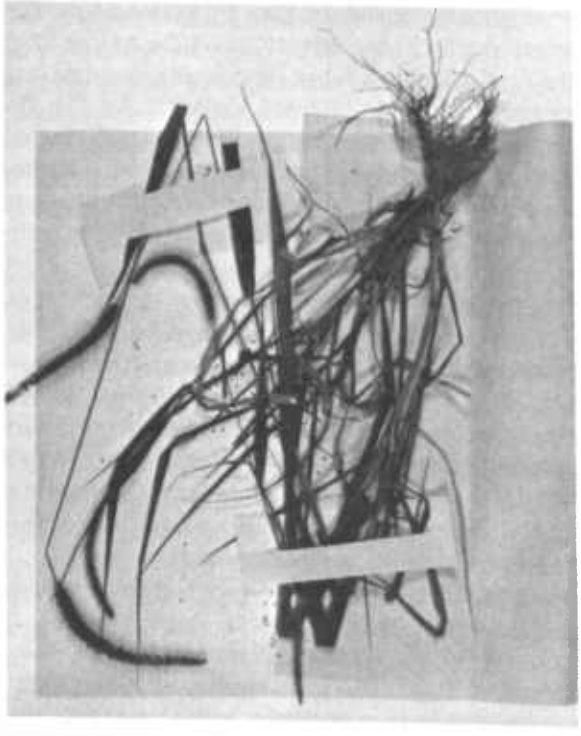

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FIGURE 9.—Slit strap holding a folded grass specimen.

Among the common plants of marshy areas, there will be some that are conspicuously fleshy. These will generally collapse and dry to make a satisfactory specimen without special treatment if the press driers and corrugates are changed frequently enough. Parts of a few fleshy plants, for example, the outer hood (spathe) over the clublike flower mass of the skunk cabbage (*Symplocarpus foetidus*), are crisp when fresh and break in the press. The final specimen bears little resemblance to the plant seen in the field. To prepare specimens of this kind, cut sections to show important features and dry the sections in the usual way. Drying will be facilitated by dipping the sections in formaldehyde solution, alcohol, or boiling water to kill the cells and permit moisture to escape quickly. If the final specimen does not allow the botanist to reconstruct the plant part, it should be supplemented by a sketch or photograph of the plant before it was sectioned. For success with specimens of this kind, the driers must be changed as frequently as they become moist (once a day initially).

Among the first plants collected by the novice are those with large, colorful flowers. Many large flowers will dry quickly and retain color well. A few, like the day flowers (Commelinaceae), deliquesce (melt away or become liquid) in the press. Other large flowers, including the morning-glories, iris, and lilies become so thin that it is almost impossible to remove the specimen intact from the pressing sheet. If tissue paper is placed above and below the flower as is goes into the press, the flower can usually be peeled from the tissue without damage. If the specimen can be hardened by a quick dip into a solution of formaldehyde, there will usually be no difficulty in preparing a satisfactory specimen of difficult-to-press flowers, but formaldehyde may not be available to the casual collector.

Some plants produce fruits that are too large and fleshy to be placed directly into the press. Large, hard fruit like walnuts are easily dealt with by spreading them out on a dry surface for a few days. Large, fleshy fruits require a similar technique to that used for fleshy plants like the skunk cabbage, discussed above. Because there will be shrinkage, large fruit should be measured and then cut so that longitudinal and cross sections may be dried in the press. To prevent sticking, use a piece of thin, oiled or waxed paper, barely larger than the fruit section, on either side. Too large a piece of oiled or waxed paper will prevent the escape of moisture and lead to the development of mold on the specimen. Tissue paper can sometimes be used successfully, but it may become so firmly imbedded in the cut surface that it cannot be removed. Again, the use of a fixative to accelerate the drying is recommended.

SPECIAL METHODS FOR PREPARING HARD-TO-PRESS HERBARIUM SPECIMENS

The collecting method described on pages 3 to 15 is the one most generally used, particularly by the average collector. The equipment is inexpensive and easy to handle although it may become bulky if a large number of specimens must be processed. To accommodate special problems and to process collections under difficult climatic conditions, a number of special methods have been developed.

Wet Collection for Field Use

Originally developed in the Old World Tropics by European botanists, the use of preserving fluids has seldom been extensively practiced by collectors in temperate areas. Their use can be effective because they enable the collector to eliminate a large amount of the paraphernalia ordinarily carried into the field to dry specimens.

Preserving Fluids Used

Several preserving fluids have been recommended in the last few years. Moore (*17*) advocated the use of hydroxyquinoline sulphate (1 percent aqueous solution). Specimens are trimmed as usual and placed in press sheets separated by a drier. After the material has been wilted for a period (overnight is suggested), the specimens are removed from the sheets one by one and dipped into the preservative. The specimens are replaced wet in the press sheets, which are then bundled into a package of convenient size between corrugates, tied, and wrapped in waterproof sheeting (rubberized cloth or plastic sheeting). Since this solution has proved suitable to preserve fresh flowers and fruits for several months in glass containers, plant specimens in sheets would probably keep satisfactorily as long as the cover of the package was intact and the preservative did not dry out. However, the staff of the National Arboretum has recently found that preservation in hydroquinoline is less satisfactory than in other fluids.[2]

After the bundle has been transported to a central base or to its final destination, it is opened and the wet press sheets are placed in a plant press between driers and corrugates and dried in the usual manner. Moore states that the solution is "most satisfactory" without noting its effect on the color of plant parts.

Thieret (*27*) found that the hydroxyquiniline solution does not kill plant tissue quickly enough to prevent the formation of abscission layers, so that petals and leaflets tend to drop. The material is apparently nontoxic and does not attack animal skin, so it is safe to handle. In addition, the chemical is carried in powder form, so a considerable amount weighs little.

Hodge (*12*) has used and recommends alcohol as a general field preservative for herbarium specimens. After the plants are placed in press sheets, the sheets are moistened with locally available distilled alcohol and packed into a waterproof container. In this technique plant specimens are not pressed beforehand. The container mentioned by Hodge was a metal box with a lid sealed into place with surgical tape, which was then waxed to improve the seal. Again, as long as the seal was tight, the speci-

[2] Personal communication.

mens remained moist and pliable although preserved. After arrival at a central point, the sheets were placed in a press and dried in the usual manner.

Because the alcohol content of most distilled beverages ranges between 30 and 50 percent, preservation of plant material is assured. Alcohol causes many color changes in the specimens, so field notes have to detail colors carefully. Handling alcohol-preserved press sheets tends to dry the skin. Alcohol kills plant tissues immediately, preventing the formation of abscission layers and dropping of parts. Because alcohol is usually available locally and generally quite inexpensive, it does not have to be transported very far. Unfortunately, if the bundle of specimens is not properly sealed, mold will develop on the specimens.

Schultes (*24*) discusses the use of formaldehyde as a field preservative. Plant specimens are prepared and placed in the press overnight. Originally, Schultes dipped each specimen into a solution of two parts of commercial formaldehyde diluted with three parts of water. I find that the folds holding the specimens need only to be moistened at the center underneath by a quick dip into the solution. Other botanists immerse a stack of folds with specimens in a stronger solution (1:1) of formaldehyde. The stack of specimen folds are then tied tightly between corrugates and wrapped in waterproof sheeting or placed in an airtight plastic bag to prevent drying. I have stored specimens for as long as 6 months in this way. When it is convenient, the folds are placed in a plant press and dried in the usual way at a central base or at the final destination of the plant material (fig. 10).

The folds of newsprint need only be dampened with the formaldehyde solution because preservation is accomplished by formalin gas. Newsprint that is thoroughly sodden becomes pulpy and it is virtually impossible to separate the individual sheets. Furthermore, too much fluid adds much weight to the bundle.

The use of formaldehyde has several disadvantages. It, like alcohol, must be carried in liquid form, A dry chemical, frequently called paraformaldehyde, has been suggested as a more easily carried source of formalin. At the time I first considered using a wet-collecting technique, I asked a chemist to recommend the

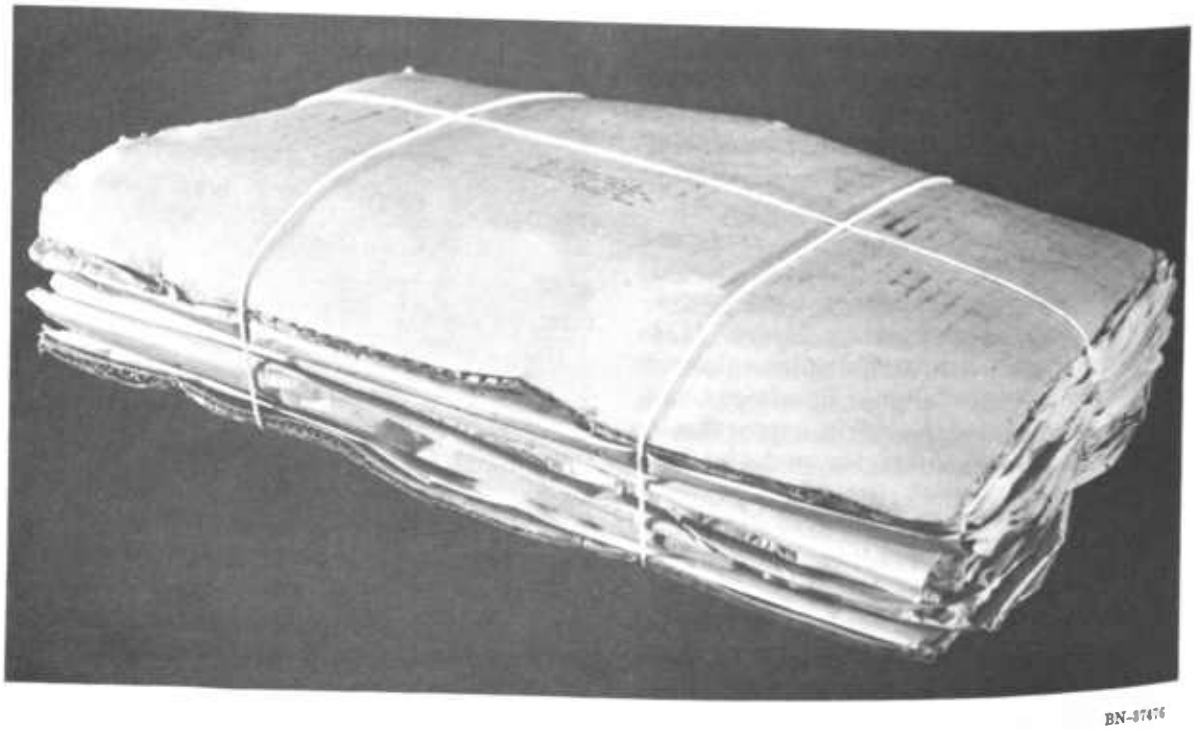

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FIGURE 10.—Bundle of specimens reinforced with corrugated cardboard and tied for storage or shipment.

best method of preparing formalin from the powdered chemical. His experiments proved that a formalin solution of usable strength could be obtained only by use of heat at a controlled temperature and buffering of the solution to a precise pH, conditions that are nearly impossible to obtain in the field. Formaldehyde is an indiscriminate preserver of all biological material and will damage the skin of an incautious user. If rubber gloves are not available or are too awkward when placing the wet sheets in the press, a heavy coating of petroleum jelly on the hands will prevent damage. When formaldehyde is used in an unventilated area, fumes cause the eyes to tear and can cause inflammation of the nose and throat. Formaldehyde changes the depth of the green color of leaves and alters some flower colors completely, so good color notes must be taken before the plants are pressed.

A number of unjust charges have been leveled at the use of formaldehyde as a preservative. Color changes are not as marked as many people have stated. The color of specimens in the herbarium fades with time anyway, so this is not a serious defect provided color notes are accurate. The statement is often made that formaldehyde makes material brittle, probably because it is known to harden animal tissue. This is not true. Before plant specimens preserved in formaldehyde are dried, they remain flexible and crumpled leaves and petals can be straightened at will. After they are dried, the specimens are no more brittle than those prepared by any other method. In fact, specimens of loranthaceous plants, which are notoriously brittle when dried without a preservative, hold together very well when placed in a solution of formaldehyde before pressing.

Fosberg (*9*) recommends the use of a solution of one part of 40 percent formalin to two parts of 70 percent alcohol to preserve plant specimens. He paints this onto the specimen with a 2-inch paintbrush. The advantages to be gained are said to be better wetting of the specimen and better penetration of the preserving fluid. However, the disadvantages of both preservatives are retained as well as the further disadvantage of having to transport another liquid.

Still other liquids are used to preserve plant material. Kerosene and gasoline, both of which may be more readily available than formaldehyde, are used as dips to kill plant tissue and to aid in its drying and preservation. With either of these liquids, the specimen is dipped, drained, and placed in the press sheet without the addition of enough liquid to wet the paper. Obviously, artificial heat cannot be used to hasten the drying until all fumes from the preservative have evaporated. The use of flammable organic solvents for preserving is hazardous because of fire danger and because they may constitute a health hazard in unventilated areas; thus any of the previously mentioned preservatives are preferred over kerosene and gasoline.

Equipment Needed

Mention has already been made of the press frames, driers, and corrugates needed when several of these preservatives are used. Because the bundles of plants are packed wet, only enough press supply to hold specimens for 24 hours needs to be carried into the field. A collector preparing 5 to 10 duplicate specimens of every number will rarely be able to collect and prepare more than 100 numbers per day, even with good field assistance. When working alone, a collector will usually find that about a third of the amount will provide a hard day's work. Far fewer numbers of difficult-to-prepare specimens can be handled. The amateur collector or the collector who is preparing only an occasional specimen in conjunction with another project will rarely need press space for more than 50 sheets of plants per day. This brief estimate of daily press capacity can serve only as a guide and must be adjusted by experience.

In general, then, enough driers are needed to furnish at least one for every specimen put in the press. Enough corrugates are needed to allow two on each side of every large woody specimen inserted between more delicate, herbaceous specimens or one per specimen when all of the material going into the press is woody and intractible. Because corrugates will be used as covers for bundles for storage, extra corrugates must be allowed for this purpose. One sheet of folded newsprint is needed for every specimen placed in the press. Finally, two press frames and two straps or ropes are needed for

every 60 to 90 thin specimens or for every 50 or fewer woody specimens. Under some circumstances, it may be possible to pack more specimens than this into a single press, but only a few woody specimens make uneven press piles that tend to squirt out the side when pressure is applied.

For field use, nothing can exceed the value of plastic containers for handling liquids. The use of all these preservatives requires the mixing of solutions or the transporting of liquids. Since a gallon or less of prepared solution is needed for most days' work, a 1-gallon plastic jug is required to mix and store the liquid. For dipping sheets, a plastic photographic tray of the size used in processing 11- by 14-inch prints is convenient. This size allows the underside of a fold of newssheet to be thoroughly wet. When formaldehyde or alcohol is carried into the field, metal or plastic stock containers should be used. Usually, the containers furnished by the manufacturer will be accepted by surface carriers for transport. If supplies must be shipped by air, regulations require that substances like formaldehyde be packed in small quantities and especially marked. In this case, frequently it is more convenient to repackage the stock liquid in plastic quart bottles. Advantages of the repacking include ease of packing, the lack of breakage when supplies must be transported on pack animals, and the high value of empty plastic bottles among the rural people of most countries outside the United States.

Because bundles of specimens must be kept moist until ready for final drying, a supply of liquidproof sheeting or large plastic bags must be available. Plastic bags large enough to hold several bundles of 100 to 150 specimens each can be furnished by dealers in polyethylene tubing. Tubing 4 mils thick and 30 inches wide can be ordered cut to the desired length and sealed at one end. Large plastic bags immediately lend themselves to additional uses as collecting bags in the field, ground covers, or even temporary raincoats with holes for the arms and head cut in the bottom.

When it is necessary to dry specimens prepared by the wet-collecting method using formaldehyde, it is desirable to have an enclosed drier from which the fumes can be vented to the outside. Plans for a very satisfactory drier with a temperature controller are shown in figure 11. In the homemade drier from which these plans were devised, the original cabinets were wooden, half-size herbarium cases from which the backs were removed so that they could be joined to form a continuous chamber. Heat was provided by electric air heaters with fans controlled by a temperature controller so that the heat underneath the press never approched the boiling point of water by many degrees. A small fan in the vent stack ran continuously while the drier was in operation, ensuring that the air moved steadily through the press.

Suggested Techniques for Preparing Hard-to-Prepare Herbarium Specimens

Although the amateur who collects plants for pleasure is not likely to wish to collect many of the troublesome plants discussed below, he may find here a hint to help him in preparing specimens of some of the less commonly collected plants. For instance, discussion of the treatment of succulent xerophytes (see p. 20) will apply equally well to any other succulent plant. To avoid repetition, this section will be divided into discussions of a general problem to be met in several groups of plants.

Floating or Submerged Aquatic Plants

It is singularly difficult to prepare representative specimens of many floating and submerged aquatic plants because the entire plant body is normally supported by water and it tends to collapse almost completely when removed from water. To this is added the difficulty of straightening leaves that are divided into many filiform segments. To reduce the amount of arranging to a minimum, float aquatics in a large, shallow vessel or tray (fig. 12). Slip a sheet of paper (preferably a good grade of bond) under the specimen and then gently lift it as nearly level as possible so that the water drains away slowly. If this is carefully done, the plant will be well distributed across the paper and most of the leaves will be spread. If the first attempt is unsuccessful, the plant and sheet may be returned to the water. When ready for the press, the sheet of paper bearing the plant specimen is put into a fold in the usual

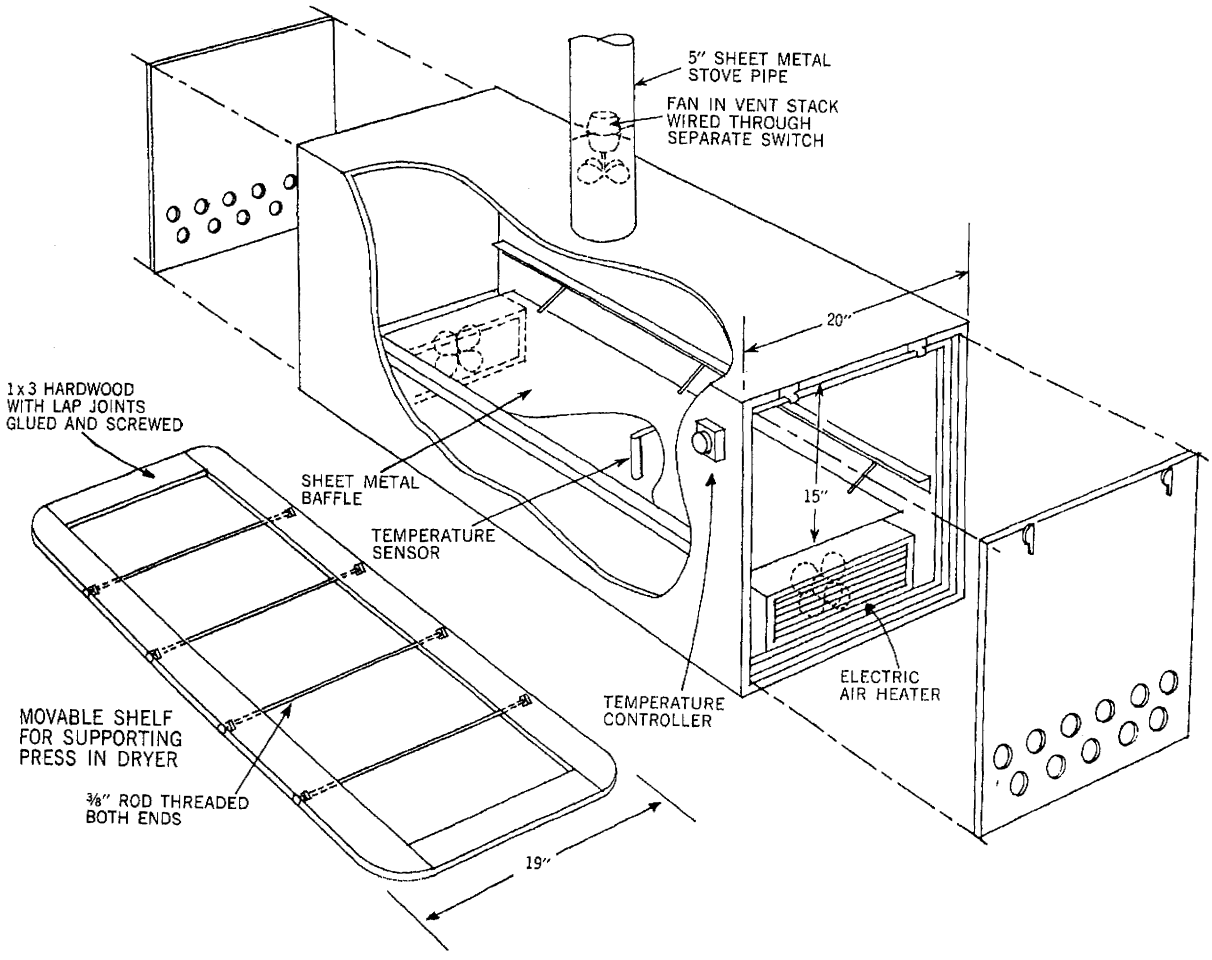

FIGURE 11.—Design for a completely closed plant drier with forced draft ventilation for drying specimens preserved with alcohol or formaldehyde. The stack should be vented to the outside.

way. If the specimen appears to be mucilaginous, as many aquatic plants tend to be, either tissue or thin waxed or oiled paper may be laid over the specimen before closing the fold to prevent the specimen from sticking to the newsprint. The specimen is then dried in the press routinely. When removing the specimen after drying, peel the covering protective paper carefully, but allow the specimen to adhere to the underlying bond paper and mount the specimen on the herbarium mounting paper without disturbing the specimen.

If many aquatic plants are to be collected, a rectangle of ¼-inch hardware cloth cut to about 11 by 15 inches can be used to lift plant specimens from the water directly on a piece of paper. The paper is slipped into a newsprint fold and dried without disturbing the specimen.

Plants With Large Parts

Sometimes the most nearly representative specimen of a plant will include parts that are either too long and wide or too bulky to be placed in the press. (See Appendix I for plant features to be illustrated by prepared specimens.) In some instances, as with pine cones, the structure is woody. This causes no difficulty because the part that doesn't fit may be removed from the branch, tagged with the same field number as the pressed specimen, dried, and later placed in a box for filing. If it is desirable and facilities are available, the back half of a pine cone may

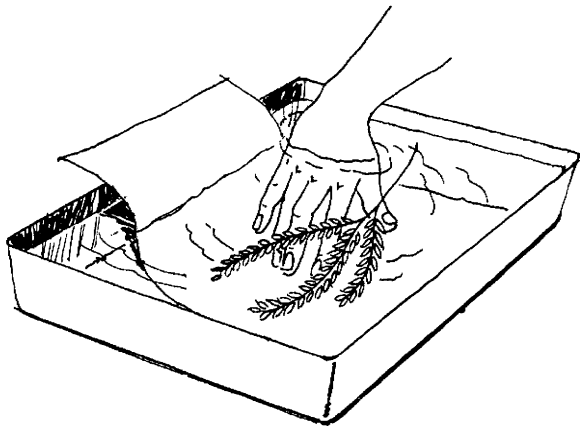

FIGURE 12.—Use paper to lift submerged aquatic plant specimen.

be removed with a fine-toothed saw so that the cone may be left attached to the specimen without disrupting the press unduly. Unfortunately, not all large plant parts are so easily made into specimens.

LARGE FOLIAGE.—The typical foliage of a number of plants is larger than the 12- by 16-inch herbarium mounting paper will accommodate. This is particularly true of tree ferns, aroids, bananas, gunneras, and palms, the last of which will be discussed separately. (See p. 24.) In general, leaves are bilaterally symmetrical, so one-half of the leaf may be cut away to one side of the midrib or central leaf vein without destroying its value as a specimen. If the rest of the leaf is still too large to fit the press fold without bending more than once, it will probably be necessary to cut the lamina and petiole into several pieces, pressing each in a separate fold. (See p. 6.) All folds must bear the same field number, and if there is any chance that the sections cannot be oriented so that they may be reassembled to show the original outline of the half-leaf, these folds should be serially marked with letters or with Roman or arabic numbers in parentheses. It is always better practice to photograph or sketch the leaf before dividing, making sure that a scale is included, so that the original dimensions can be calculated.

LARGE FRUIT.—Many plants bear fleshy fruit that either does not press easily or does not press at all. Since the shape of irregularly shaped fruit is very difficult to describe, such fruit should be photographed or sketched with a scale and color notes recorded. The fruit can then be divided into both longitudinal and cross sections, with sufficient outer surface preserved to clearly show the character of the skin (fig. 13). These sections are placed in the press with tissue or oiled or waxed paper on either side so that the section will not adhere to the newsprint fold in which it is dried. The protective paper should be cut as small as possible because large sheets of oiled paper on either side of a section will effectively seal around the section and prevent the moisture from escaping. Sections of this kind not only show the general shape and dimensions of the fruit, but also show the size and placement of the seeds.

BULKY ROOTS OR STEMS.—On occasion it will be necessary to prepare specimens of plants whose roots or stems are modified into storage areas and are generally greatly thickened. Because these will bulk unnecessarily large in the press, they also should be photographed or sketched with a scale and divided into sections for pressing. Frequently tissue of this sort does not present the problem of stickiness encountered with fruit, so protective paper on the sides of the sections will not always be needed. If the piece to be preserved is woody, it can be dried whole and later sectioned with a saw. In this case, the specimen must bear the same number as the portions of the plant placed in the press.

Succulent Xerophytes

The largest percentage of succulent plants, i.e., plants in which the stems or leaves, or both, are highly modified to store quantities of fluid, are found in semiarid or arid regions around the world. Thus, they are xerophytes. Even the hobbyist is tempted to press some of the bizarrely shaped plants, many of which bear large, colorful flowers. Succulent plants are especially adapted to take up and retain fluid for long periods and this capacity is maintained in the plant press. The family Cactaceae in the New World is noted for members that are resistant to drying.

A camera or a facility for making accurate drawings is essential to the proper collection of many succulent plants. A scale must be included with the illustration because the plant tissue

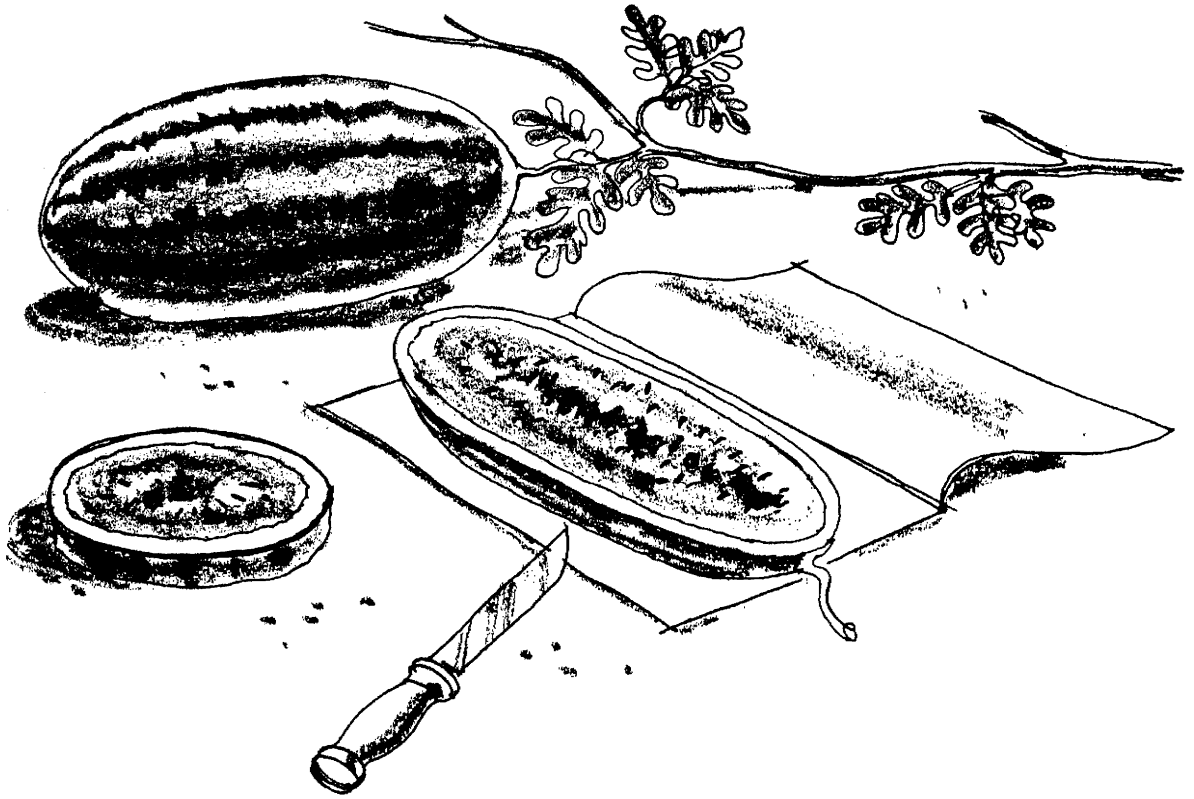

FIGURE 13.—Make longitudinal and cross sections of fruits that are too large to press entire.

shrinks very much with drying. Along with the illustration, color notes are needed, particularly for flowers and fruit. A general habit illustration may not always be essential to the identification of the plant, but it frequently is useful because many of the larger succulent plants have characteristic forms of branching.

Once the illustrations have been made, sections of the plant bearing flowers or fruit are cut to a length that will fit into the press (fig. 14). Large plants like the arborescent cacti and euphorbias have stems much too thick to be pressed whole; these must be sectioned both crosswise and lengthwise, taking care to show at least one section with the point of attachment of a flower or fruit. Because the reproductive structures may also be fleshy, they too must be split in half or sectioned. Whenever the fluid in the sections appears to contain a latex or mucilaginous substance, it is best to use a protective paper cut to the size of the specimen to keep the section from sticking to the newsprint fold.

Because most succulent plants lose their moisture slowly, specimens dry very slowly and mold badly. It is, therefore, essential that such specimens be treated with formaldehyde, alcohol, or other organic preservative or solvent to kill the tissue and allow the specimen to dry as quickly as possible.

Cacti of the pricklypear group with stem joints composed of flat pads present a more difficult problem because cross sections are not necessary and the pads frequently appear to be thin enough to fit readily into the press. Unfortunately, such specimens not only refuse to dry but also sprout readily, even after months in the press. Although many of the species of this group are equipped with an armament of numerous spines, the best method of preparing specimens of the pad is to cut the pad in two, parallel to the flat sides. This provides two specimens of one-half the thickness of the original pad. If these are then killed by immersion in formaldehyde, alcohol, or other organic preserv-

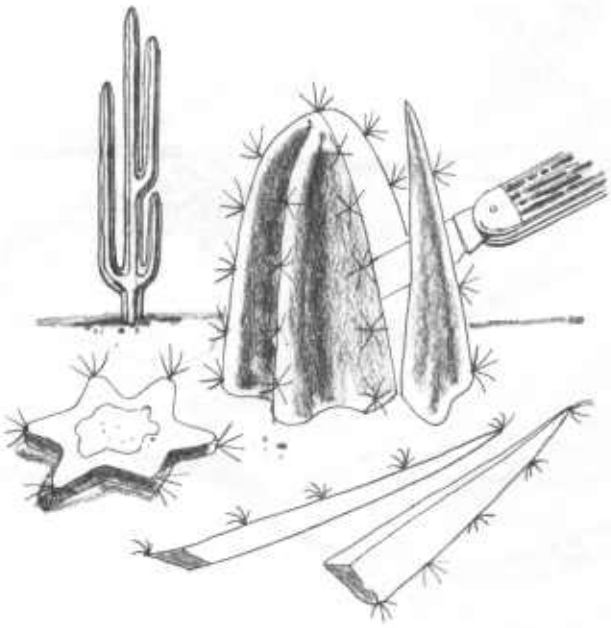

FIGURE 14.—Large cacti are cut in cross section and a single longitudinal rib.

ative, they will dry quickly and completely. Fruit is critical for the separation of some species in the pricklypears.

Members of the lily and amaryllis families with arborescent or shrubby habits frequently have large fleshy leaves borne in rosettes. Agaves bear some of the largest leaves of plants of this kind and, in addition, agave inflorescences may be 30 feet tall and 6 to 8 feet in diameter. As with other specimens, photographs or sketches, with scales, of the plant habit, a leaf, and the inflorescence, along with color notes, will eliminate much note taking. The inflorescence must be cut and representative sections of the stalk, branches, flowers, and fruit placed in the press. The flowers are particularly important to an understanding of the classification of this group of plants. Care should be taken to assure that the pieces of the plant chosen for preservation can be related to one another and to the illustration of the whole plant or inflorescence.

Leaves must be considerably reduced in bulk but the character of the margin and the shape of the whole leaf are important in classification. To preserve as much of the leaf as possible, one of two methods may be followed: (1) The entire top surface and margins of the leaf may be away from the back of the leaf (fig. 15); or the entire center of the leaf to within 1 inch the margin and basal end may be cut out 16). The first method is very good for long, row leaves because the leaf can then be fo several times to fit into the newsprint p paper. The stout fibers present in the agave will act as hinges so the leaf may be unfolde its full length when it is desirable to examin in the herbarium. The second method is pre able for short, broad leaves. As with any culent plant part, immersion in a preserva will kill the tissues quickly and allow the sp men to dry rapidly and evenly.

Succulent Mesophytes and Hydrophytes

Surprisingly enough, many mesoph (plants that grow under medium conditions moisture) and hydrophytes (plants that grow water) are succulent to the extent that care must be used in their preparation as barium specimens. The succulence of most these plants is confined to the rootstalk, st or leaf petiole, as in members of the ginger the banana family. If the plant is particu large and must be divided into a number parts for pressing, the usual record of the

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FIGURE 15.—Cutting away entire back of agave leaf that it can be pressed.

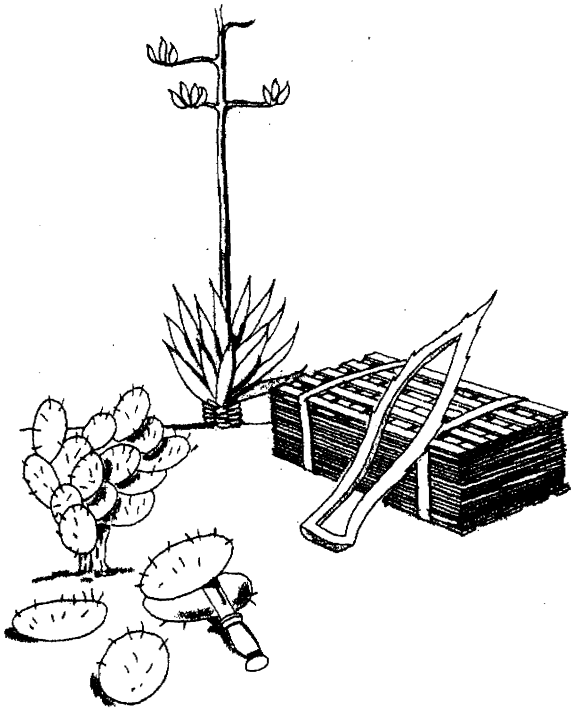

FIGURE 16.—The entire center is cut out of short, wide agave leaves.

and the size and shape of parts by means of photographs or sketches is needed. In general, the thick member is then split down the middle and both halves are pressed. Immersion in a preservative or solvent will insure quicker drying and better specimens. Again, good color notes are essential.

The orchids present some special problems. Many of the orchids have fleshy stems or pseudobulbs, which are not quite thick enough to warrant splitting but which are very retentive of moisture and thus do not dry well. Some of the orchids have large flowers with fleshy petals of unusual shapes. These neither look much like the unpressed flower when they are removed from the press, nor are they very quick to dry; and they frequently mold. Drying of the stems and pseudobulbs can be hastened by cutting a series of small slits in the outer surface before pressing. Flowering material is best prepared by immersing the specimens in formaldehyde or alcohol. The drying time is much shorter, there is no molding, and the preservative helps retain the shape of the flower parts. Photographs and color notes are necessary for parts with unusual shapes or sizes.

Plants With Deliquescent or Fragile Flowers

The flowers of many plants are difficult to preserve so size and shape of the parts may be seen and studied. Many of the day flowers (Commelinaceae) are deliquescent (tend to melt away or become liquid by attracting and absorbing moisture from the air) and break down completely unless they are picked very early in the day and pressed immediately. Flowers of iris, lilies, hibiscus, and many other plants with large petals or thick texture, or both, tend to either rot in the press or stick to the fold in which they are pressed, and then the petals tear as they are removed. Pieces of tissue paper cut to the size of the flowers will facilitate their removal from the press sheet. If color retention is very desirable, the moisture can be rapidly removed from a single flower by placing it between blotting paper pads and heating it with pressure by an ordinary electric clothes iron. However, this is not practical for a number of specimens. The most practical method of preparing such flowers is by immersing the specimen in a preservative before pressing. Many pigments will not be changed appreciably by this and a much better preserved flower will result. It should be noted that white in flowers is a lack of pigment; consequently, when the physical structure of the tissue is changed by drying, its light-reflecting qualities change so that white areas then appear tan or brown.

Plants of the Pineapple Family

Species of plants belonging to the pineapple family (Bromeliaceae) present a rather unique problem in that the plant body is generally a rosette of leaves that is frequently large and nonsucculent but very resistant to drying. This rosette is topped by an inflorescence often much too large to fit easily into a press fold. The procedures for sectioning previously outlined do not work well on rosettes. For these plants, the best procedure is to peel the rosette apart, selecting representative leaves for the press (fig. 17). The stem and inflorescence that remains then can be placed in the press as it is or if it is too large, can be split from the base to the

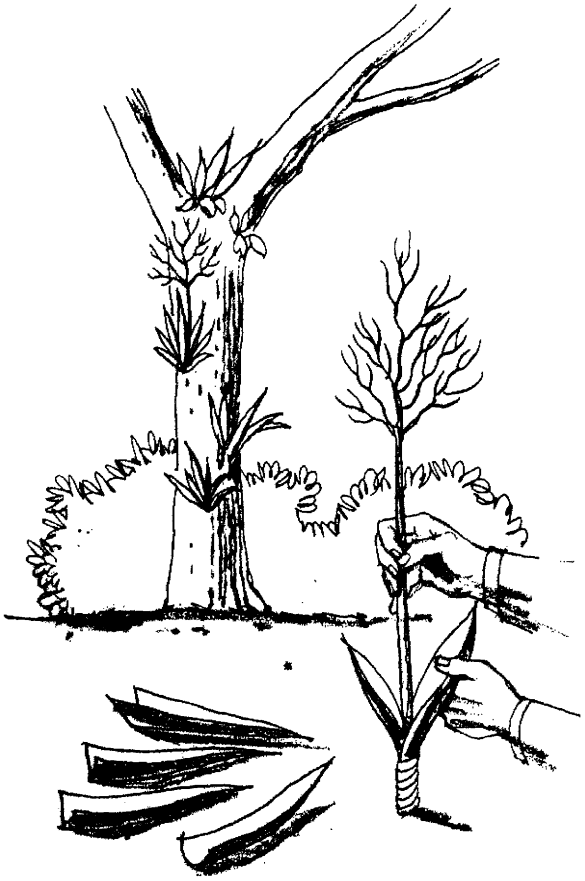

FIGURE 17.—Rosettes of species of the pineapple family are pulled apart and individual leaves and inflorescence are pressed.

apex yielding two specimens of about equal size. Some species of the family produce very large inflorescences that must be handled by sectioning, like the agave inflorescence. (See p. 22.) Flowers are generally more important than fruit for identification of members of the Bromeliaceae. As noted before, whenever a plant must be divided or sectioned, photographs or sketches with scales should be made first.

Plants of the Palm Family

Preparing plants of the palm family (Palmae) is difficult for the field botanist in tropical areas. Some palm species are small plants of the forest floor and will fold to fit into the press sheet. But by far the largest number of palms bear leaves that can only be described as gigantic. Frequently, the inflorescence is as large as the foliage. Much of the difficulty encountered in the classification of palms stems directly from the inadequacy of the specimens available for study. L. H. Bailey (*2*) discussed this problem and the preparation of palm specimens; his recommendations are still valid.

Before attempting to collect palm specimens, the collector must become thoroughly familiar with the operation of a camera. The plant furnishing the specimen should be photographed before any part is cut. Each frond and inflorescence destined for the press must be photographed before it is divided. Every piece of an individual tree must be tagged with the same field number because it is generally necessary to cut each leaf or inflorescence into many small pieces to get them into the press. Like other large leaves, palm fronds are bilaterally symmetrical, so one-half of the leaf can be trimmed away. The rest must be divided into portions, taking particular care to make good specimens of the top and base of the frond and the base of the petiole as well as intermediate samples from the rest of the leaf. In many palms, the inflorescence emerges from a sheath or series of sheaths. These are important to the classification of the plant and must be preserved along with portions of the inflorescence showing both male and female flowers, fruit, and enough of the basic structure to show the general configuration and method of branching.

Because both the bromeliads (see p. 23) and the palms are resistant to drying, they are much better preserved if they are placed in formaldehyde or alcohol before they are pressed. If there are many of these or similar plants to be processed, it is strongly recommended that a preservative be used for all specimens and the final drying of the specimens be delayed until they can be handled at a permanent installation with drying facilities employing heat. The habitats in which many of the hard-to-press plants grow are subject to hard-to-predict weather that frequently makes field drying very uncertain.

Bamboo Plants

The woody grasses commonly called bamboo are another distinctive group of plants that causes the collector considerable difficulty. The classification of the bamboo species depends upon vegetative structures because many bam-

boos flower only once in a lifetime and then promptly die. Photographs of the clump before specimens are taken and photographs of parts before they are divided for the press are needed. A mature culm is then cut to obtain the mid-culm sheaths and branch complement and a specimen with two nodes and the internode. On all of these, the number of the node above the ground should be recorded. The rhizome should be dug and photographed so the manner of branching is apparent; sections are then preserved. Because many of these parts will be too large or too bulky to fit into a plant press, the collector should mark the separate pieces with the field number and a serial section number before dividing the plant so the specimen can be reconstructed. If flowering material is available, a series of specimens showing the range of variation of the parts of the inflorescence should be collected. Young shoots should also be collected. Since two different species of bamboo in adjacent clumps may intergrow, care must be taken to collect all portions of the specimen from the same plant. Immersing in a preservative will kill the tissue and result in quicker, more uniform drying of the specimens.

Screwpines

Another group in which special collection problems occur is the genus *Pandanus*, more familiarly known as screwpine. The group is widely distributed in the Old World Tropics. A better understanding of the relationships of the species of the genus depends upon improving the quality of collections of the group.

Screwpine, like a number of other plants, is always dioecious as far as is now known. (See Appendix II.) Whenever members of this group are collected, an effort should be made to find both sexes under circumstances that indicate the relationship of the two plants. If male plants cannot be demonstrated to be associated with female plants in the same colony, they are of little value, because the more critical determinations are made on the basis of the fruit.

The fruits of the female plant of some species may be small enough to be left on the plant when it is placed in the press. Many species, though, bear very large heads of fruit that may be solitary or in spikes. As with other large plant parts, fruiting heads should be photographed or sketched, preferably with a scale, before they are divided. The heads frequently must be split in half longitudinally before drying. When mature, the fruits are generally soft and fleshy and they will dry more quickly if immersed in a preservative. If supplies are available, representative parts may be bottled in preservative, but most field collectors will find that drying the representative parts is sufficient.

Screwpine leaves are usually borne as a spiral of lanceolate leaves on a thick stem. Disks of the stem should be cut free and the entire leaf, including the sheathing base and the unbroken tip, folded into the press sheet. Photographs or sketches of the vegetative parts should be made before the leaves are removed.

In addition to the foliar and inflorescence material, a sample of the mature bark and sections of prop roots should be included in the collection. As with all collections in which diverse samples are to be handled in different ways, it is imperative that all parts of a collection be identified with the collection number in such a way that parts of the collection do not go astray.

Arborescent Plants

Although many of the suggestions that have been discussed in relation to specific problems apply generally to other arborescent (treelike) species, it is worthwhile to emphasize some suggestions.

Among the foremost of these is the recording of the overall aspect of a very large plant. Identification must, of necessity, be based on the small sample placed in the press, but collectors today have little excuse for ignoring the habit of large plants. Photographs of the tree to show it from base to top are needed to demonstrate many features unless the collector wishes to write lengthy notes describing the appearance of the base, the character of the trunk, the method and density of branching, and the size and shape of the crown. If at all possible, detailed photographs of the bark, base, and branching are frequently helpful and will provide information that is lacking on most older herbarium specimens.

At times, photographs or sketches showing the buttressing of the base of a tree, bark details, or cauliflory can save the collector many tedious

notes. Unless the collector works with a restricted group of plants over a long period of time, details observed in the field are soon forgotten. Unfortunately, color films in general use cannot be relied upon for color notes because the dyes either reproduce the color inaccurately or fail to reproduce it completely.

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APPENDIX I

General Guide to Features to Be Illustrated by Prepared Specimens

Not all members of the following families will have to be treated as suggested. Although either fruit or flowers may be critical for the identification of some groups, if available, both should be collected.[1]

Family	Dimorphic foliage	Flowers	Fruit or sporangia	Rootcrown	Section	Use fixative
Acanthaceae		X				
Aizoaceae		X		X		WP
Amaranthaceae			X	X		
Amaryllidaceae		X		X	Lf,In	WP
Annonaceae			X		Fr	Fr
Aponongetonaceae	X					
Aquifoliaceae			X			
Araceae	X		X		Lf,In	WP
Araliaceae			X	X		
Araucariaceae			X		X	Lf
Asclepiadaceae		X	X		X	
Begoniaceae		X	X	X		WP
Betulaceae			X			
Bignoniaceae		X				
Bombaceae		X				
Boraginaceae			X	X		
Bromeliaceae		X			Lf,In	WP
Burmanniaceae		X		X		WP
Burseraceae			X			
Butomaceae				X		
Cactaceae		X	X		St,Fr	WP
Cannaceae		X		X		In
Caprifoliaceae		X	X			
Celastraceae			X			
Cephalotaxaceae			X		Fr	Lf
Ceratophyllaceae	X					
Chenopodiaceae			X	X		
Combretaceae		X				
Commelinaceae		X		X		Fl
Compositae		X	X	X		
Convolvulaceae		X				Fl
Crassulaceae		X				WP
Cruciferae			X	X		
Cucurbitaceae		X	X		Fr	Fr
Cupressaceae			X			
Cyatheaceae			X		Lf	
Cycadaceae			X		Lf,Fr	WP
Cyclanthaceae		X			Lf,In	Fl
Cyperaceae			X	X		
Dicksoniaceae			X	X	Lf	
Dioscoreaceae		X	X			
Ebenaceae			X		Fr	
Equisetaceae			X	X		
Ericaceae		X	X			
Euphorbiaceae		X	X	X	St	WP
Fagaceae			X			
Flacourtiaceae		X	X			
Gentianaceae		X		X		
Geraniaceae		X	X	X		
Gesneriaceae		X		X		
Gramineae			X	X		
Guttiferae			X		Fr	WP
Haloragaceae	X					
Hippuridaceae	X					
Hydrocharitaceae	X					
Hydrophyllaceae		X	X	X		
Iridaceae		X		X		
Isoetaceae			X	X		
Juglandaceae			X			
Juncaceae			X	X		
Labiatae		X	X	X		
Lauraceae			X		X	Fr
Leguminosae		X	X	X		Lf
Lentibulariaceae	X	X	X	X		
Liliaceae		X		X		Fl
Loranthaceae						WP
Lycopodiaceae			X	X		
Malpighiaceae		X	X			
Malvaceae		X	X			
Marantaceae		X		X		

See footnote at end of table.

Family	Dimorphic foliage	Flowers	Fruit or sporangia	Rootcrown	Section	Use fixative
Marattiaceae			X			
Marcgraviaceae	X					
Melastomataceae		X				
Meliaceae			X			
Moraceae			X		Fr	
Musaceae		X			Lf, In	WP
Myristicaceae			X		Fr	
Myrtaceae			X			
Najadaceae	X					
Nyctaginaceae			X	X		
Nymphaeaceae		X				WP
Oleaceae			X			
Ophioglossaceae			X	X		
Orchidaceae		X				WP
Osmundaceae			X	X		
Palmae		X	X		WP	WP
Passifloraceae		X			Fr	
Pinaceae			X			Lf
Piperaceae						Lf
Plantaginaceae			X	X		
Polemoniaceae		X	X	X		
Polygalaceae		X				
Polygonaceae			X	X		
Portulacaceae						WP
Potamogetonaceae	X					
Psilotaceae			X	X		
Rhamnaceae			X			
Rosaceae		X	X	X		
Rubiaceae		X	X			
Rutaceae			X		Fr	
Sapindaceae			X			
Sapotaceae			X		Fr	
Schizaeaceae	X		X	X		
Selaginellaceae			X	X		
Simaroubaceae			X			
Solanaceae		X	X	X	Fr	
Sparganiaceae			X	X		
Sterculiaceae			X			
Taxaceae			X			Lf
Taxodiaceae			X			Lf
Theaceae		X				
Tiliaceae		X	X			
Turneraceae		X	X			
Ulmaceae			X			
Umbelliferae			X	X		
Verbenaceae		X	X			
Violaceae		X		X		
Vitaceae			X			
Xyridaceae		X	X	X		
Zingerberaceae		X	X	X	Lf In	In

[1] Fl = Flowers. Fr = Fruit. In = Inflorescence. Lf = Leaves. St = Stem. WP = Whole plant.

APPENDIX II

Plants With Unisexual Flowers

Some or all members of the following plant families bear male and female reproductive organs in separate flowers. These may be in the same inflorescence, on different areas of the same plant, or on separate plants. Care should be exercised to obtain specimens of both sexes if possible.

Batidaceae
Begoniaceae
Betulaceae
Buxaceae
Caricaceae
Casuarinaceae
Cercidophyllaceae
Chloranthaceae
Cornaceae
Cucurbitaceae
Cyclanthaceae
Datiscaceae
Dioscoreaceae
Ebenaceae
Elaeagnaceae
Empetraceae
Eucommiaceae
Euphorobiaceae
Fagaceae
Flacourtiaceae
Garryaceae
Gnetaceae
Guttiferae
Hamamelidaceae
Hernandiaceae
Juglandaceae
Lardizabalaceae
Lauraceae
Leitneriaceae
Loranthaceae
Menispermaceae
Monimiaceae
Moraceae
Myricaceae
Myristicaceae
Myrsinaceae
Najadaceae
Nyctaginaceae
Nyssaceae
Pandanaceae
Phytolaccaceae
Platanaceae
Proteaceae
Rafflesiaceae
Salicaceae
Santalaceae
Schisandraceae
Ulmaceae
Urticaceae
Valerianaceae

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